CONSERVATION OF SOIL FERTILITY AND SOIL FIBRE

REPORT OF CONFERENCE

Commission of Conservation
Canada

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CONSERVATION OF SOIL FERTILITY AND SOIL FIBRE

Report of Conference held at

Winnipeg, Manitoba

July 14, 15 and 16, 1920

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Commission of Conservation

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CONTENTS

natural resources might be consecrated for our use, not to be abused, not to be dissipated, not to be wasted, and that the people of Canada so using them may be employed in the protection, the development and general service of our country. Why should it in any respect barter its future for its present wasteful enjoyment?

"Gentlemen, you are here to consider how Canada can, while properly using, conserve her great resources, and therefore you are most cordially welcome."

Dr. Robertson extended the thanks of the conference to His Honour for his words of welcome and appreciation of the work of the Commission.

Address by the Chairman

Dr. James W. Robertson

Chairman, Committee on Lands, Commission of Conservation

IT is natural and fitting that the Conference on Conservation of Soil Fertility and Soil Fibre should be called by the Commission of Conservation; and it is timely that it should be held now, when the economic well-being of Canada depends more than ever upon preserving, increasing and realizing upon the productivity of the agricultural lands through intelligent farm management.

In 1909, the Parliament of Canada, by a special Act, constituted the Commission of Conservation, for the purpose of promoting the conservation of the natural resources of the country. The Commission is not a part of the ordinary administrative departments for which the Government is politically responsible. It is a Commission created by Parliament and charged with certain duties, upon the performance of which it is to report from time to time. Its membership includes *ex-officio* three members of the Federal Government and one member of the Government of each province. There are twenty other members appointed by reason of qualifications in scholarship, scientific knowledge or administrative experience. The following extracts from the address of the chairman at the first annual meeting of the Commission, indicate the character and scope of its duties and work:—

No Executive Powers

"The Commission is not an executive nor an administrative body. It has no executive or administrative powers. Its constitution gives it power to take into consideration every subject which may be regarded by its members as related to the conservation of natural resources, but the results of that consideration are advisory only. In a sentence, the Commission is a body constituted for the purpose of collecting exact information, deliberating upon, digesting and assimilating this information so as to render it of practical benefit to the country, and for the purpose of advising upon all questions of policy that may arise in reference to the actual administration of natural resources where the question of their effective conservation and economical use is concerned."

"The Commission is, in fact, probably the most truly national in its composition of any body that has ever been constituted in Canada."

The Commission formed within its membership standing committees for the consideration of questions in the main departments of its work. These are: Forests; Waters and Water-Powers; Lands; Fisheries, Game and Fur-bearing Animals; Minerals; Public Health and Town Planning; Press and Co-operating Organizations.

Forests and Water-Powers

During ten years of its service, the Commission has done eminently valuable work for Canada. It has been a power in educating public opinion on the urgent necessity of conserving forests against destruction by fires and in securing legislation and subsequent action towards that end. Much has also been done in taking stock of our forest resources and in making studies of the annual increase by growth.

After years of painstaking work, in the field and among Dominion, Provincial and private records, the Commission published reports on the water-power resources of Eastern Canada, the Prairie Provinces and British Columbia. Thus

it came about that the first adequate and reasonably accurate estimate of the extent and character of the water-powers of Canada is due to the work of the Commission. The Commission was the principal agency during the early years of its service through which veritable raids by private interests to get control of important water-powers, without consideration of the public interest, were frustrated. The principles enunciated by the Commission respecting the alienation of water-power have now been generally accepted by governments and by the people at large. These are: that no unconditional titles shall be granted and that every grant or lease of power shall be conditioned upon development in a specified time, public control of rates, and a rental charge subject to revision from time to time. Similar useful service has been rendered in the departments of Fisheries, Game and Fur-bearing Animals; Minerals; Public Health and Town-planning; and Educational Publicity.

Committee on Lands

Under its Committee on Lands the Commission began its work by ascertaining as fully as practicable the condition of lands under cultivation and whether the systems and methods of farming were resulting in the conservation of fertility and productivity. For several years it conducted surveys of conditions on groups of farms in representative districts in every province. The surveys were made for sixty-two groups, which contained a total of 2,245 farms. The detailed results were reported upon in the published annual reports. They revealed the fact that in many cases fertility had been and was being reduced, weeds were becoming increasingly prevalent, and systematic courses of rotation of crops were not being followed. At the same time in every group of farms surveyed, some farms stood out conspicuously as examples of conservation, and at the same time as illustrations of profitable agriculture. In consequence, one of such farms in each of the first groups surveyed in 1912-13 was chosen by the neighbouring farmers, in co-operation with the Commission, as an Illustration Farm.

Illustration Farms

The Illustration Farm was not in any sense taken over by the Commission. The illustration farmer did not receive any salary or subsidy. He agreed to accept regular visits from the agricultural adviser sent by the Commission and to put into practice on his farm only such advice or suggestions as he considered would prove profitable to him. The Commission gave a little financial assistance to encourage the use of seed grain of first-class quality and suitability, to try out the sowing of larger quantities of clover and grass seeds per acre, and to bring about more effective methods of cultivation to suppress weeds. The object of the investigation by the Commission, in co-operation with the illustration farmers, was to discover whether the combination of expert and scientific information and advice from the Commission with the profit-making methods of the practical farmer would result in the conservation of fertility, increase the profits, and bring more satisfaction to the farmer and his family from following the occupation. Meetings were held on these farms to explain the system and methods to neighbouring farmers and to demonstrate what these were accomplishing when applied, not on a Government farm, but on one such as the farmers themselves occupied and under conditions similar to those with which they had to do. The results were striking. The improvements were notable and numerous. There was a pressing demand for these Illustration Farms in other localities. But the Commission, not being an administrative branch of Government service, and having accomplished its object in pointing to an effective means of promoting conservation and profit, turned over the scheme to the Department of Agriculture. There is now an Illustration Farms Division of the Dominion Experimental Farms.

Illustration County

The success which attended the Commission's survey of farms and resultant Illustration Farms, led the Commission to conduct a survey of four counties and to select an Illustration County. The plan followed in and with the county is similar in principle to the plan adopted with the Illustration Farms. The work in Dundas county, Ontario, has still to go on two years of the five-year period for which it was undertaken.

I am confident that, as a result of this bit of experimental research in conservation, through Illustration Farms and an Illustration County, you will find Illustration Farms in every county or municipal district in Canada before many years. Moreover, the definite and definable progress made in the Illustration County of Dundas will have made such an impression that the underlying principles of the policy and plan of Illustration Farms and Counties, will be generally accepted and commonly applied. The essence of the scheme is to discover, develop, and call into use the ability and character of the best men and women of each community for local leadership; and to supplement that by helping to bring into each community the best things of any community, in proper relationship to all of the other best community services and conditions. By these latter I mean such things as good farming, good schools, good roads, good markets, good health and good community life. I have said "good," but on the Illustration Farm and in the Illustration County we want proper co-ordination of "the best," in order that all these services and conditions in the community may be good.

Further Organization Needed

For the conservation and improvement of the fertility of its lands and the production of crops and animal products in the most effective and profitable ways, Canada is, as yet, imperfectly and incompletely organized. This does not refer so much to the organization of the Departments of Agriculture of the Governments, Federal and Provincial, as it does to the lack of organized means by which the ordinary farmers may be enabled and will be induced to bring their farming up to the present level of the best farmers. The chief obstacle is that the application of the knowledge which is now possessed and used by the best farmers is, as yet, to a large extent not operative in the case of the ordinary farmers. And it must not be forgotten that the kind of management and work on the ordinary farms, by the great body of Canada's intelligent, capable and industrious rural population, is what determines the prosperity, stability and progress of the country.

Agriculture is to be regarded as a national interest as well as an occupation followed by individuals to earn their living. As a national interest very much more can be done and should be done for its further improvement. We will have to rely, in the main, on the improvement of agriculture and the further development of our other natural resources and industries to enable us to maintain prosperity, to pay our way as a nation and to pay our public debt. Moreover, in the keener competitions we are sure to meet in the world's markets we cannot expect to hold our place unless our people are as well informed, as well trained, and as well organized as others.

I venture to submit five propositions regarding organization required to help in the advancement of the average farming of the country and in the conservation of the fertility and productivity of our lands.

(1) Provision should be made, particularly by the employment of highly qualified men and women, for further research investigations in the field, in the laboratory and in the market.

(2) Experimental work should be continued and co-ordinated on Governmental Experimental Farms in trying out and comparing methods of applying knowledge, already possessed, to the practical operations of farming, in order to obtain the best economic results under the varying conditions of soils, climate, markets, labour and other available resources.

(3) Provision should be made, through competent editorial boards or committees, for compiling, studying, interpreting and publishing, in simple terms and in reasonably short form, the conclusions arrived at by reliable, adequate investigations anywhere, so far as these may be applicable, with the prospect of advantageous economic results, under Canadian conditions. Such boards or committees might be formed, in the first instance, for such large and general subjects as,—

(*a*) The relation of the physical condition and chemical composition of soils to the production of crops.

(*b*) Systems and methods of producing field crops in relation to profits and the conservation of fertility.

(*c*) The breeding, feeding and care of live stock and the marketing of animal products.

(*d*) The production and marketing of fruits and vegetables.

(*e*) The control of plant diseases and injurious insects.

I am very well aware of the great amount of useful information now in existence in the form of reports and bulletins, but even an illustration farmer has neither time nor quality of mind to glean from these the very things he needs, and the only men who can glean it and put it right are not editors of agricultural publications but an editorial board of men who have been carrying on the work themselves and are familiar with the conditions and know the needs. Out of the stacks of printed matter we are in danger of losing some of the best conclusions and information for the common people, and that is why I recommend the formation of such boards for the purpose—to give us something rather different and more serviceable than we have had hitherto.

The report of the proceedings of this conference will doubtless be a useful contribution to the literature on the first two of the subjects just mentioned.

(4) At least one Illustration Farm should be chosen by the farmers in every considerable community, on which they could see for themselves the results from the practical application of a combination of scientific information and advice from an expert with the profit-making system and methods of an experienced successful farmer.

(5) A Neighbourhood Improvement Association, or Better Farming Club, in close association with each Illustration Farm, would become a means whereby the natural leaders of the locality would be brought into full play for the development of every farm and farmer, and the improvement of the whole community.

Probable Results

Such a scheme of organization would provide the means whereby the discoveries, information and recommendations of the best institutions, the best minds, and the best work would be brought home to the average farmers with unparalleled beneficial results. It would cost a comparatively small amount of money. Its practical evolution and application offers an unsurpassed opportunity for the best brains, hands and hearts in Canada. When in full operation it might be reasonably expected to bring about an increase in the annual value of the output of the farms by from 20 per cent upward with scarcely any increase of expenditure. That estimate is not a mere conjecture. It is based on knowledge of what has already been accomplished in localities surrounding Illustration Farms. At the current range of prices 20 per cent increase would represent between $300,000,000 and $350,000,000, as the weather conditions were less or more favourable; and the fertility and productivity of the farms would be conserved and improved continuously.

Perhaps it would not be useful to have a discussion of this address now, but an opportunity will be afforded, perhaps in the afternoon session, when you have had time to read and think of it, to have some of these suggestions and recommendations discussed and probably referred to a small committee for such further consideration as they may find it convenient to give to them.

Soil Conservation and Western Crop Production

BY

DR. J. H. GRISDALE

Deputy Minister, Department of Agriculture, Ottawa

I AM put in the rather unenviable position of opening the practical side of this debate or discussion, unenviable in this sense, that I am not an expert in generalities; I have never devoted my attention to exploration in that line; I have rather attempted to deal with the practical and with the particular. You will have to excuse me therefore if I do not to-day go into generalities at any length, but get down as quickly as possible to matters of particular and practical application. I do not propose either to be academical. We have very few books and comparatively few bulletins or similar publications issued by Canadians who have had experience in soil cultivation, crop production and fertility conservation on these prairies. Hence the material upon which to base one's remarks on an occasion like this has to come from his own experience and observations, or from what he can gather from the work that he has seen done and the brief reports published of that work in Canada, particularly on the prairies. I propose to-day to deal with the subject from my own observations and from our findings, as condensed and summarised on the experimental farms with which I have been identified, until very recently, for many years.

My first experience in connection with crop production in the west dates back some twenty odd years, when we had farms on the prairies at Brandon and Indian Head only. Since then we have acquired a number more.

Soil Fertility and Increased Crops Synonymous

To begin with, conservation of soil fertility and increased crop production must go together. It is a simple matter to conserve soil fertility, if you do not have to bother about the crops, but we want, and must have, at the same time that we keep the fertility in the soil, to maintain the crop-producing power of those soils, or, if possible, to increase it. It is quite possible to do this, as has been demonstrated in many countries. The only cultural methods or crop production systems to advocate, having in view soil conservation, are those which are at the same time capable of increasing crop-producing powers. The field that from year to year is made to produce these crops should, at the same time, and probably is becoming more and more fertile rather than losing its fertility. In European countries, where fields have been under crop production for thousands of years, the crop-producing powers of the fields were greater just before the war than they ever had been before that date. Due to lack of man-power, lack of fertilizer and more or less breaking away from the regular crop rotation that had been followed successfully and advisedly on the farms in those countries, the producing power of the fields to-day in those European areas is not what it was ten years ago. No doubt, however, once things are on the old footing, the countries of Europe will be producing just as large crops as ever before and possibly larger, because they have many incentives to spur them on to greater effort, to greater thought, and to more careful operation of their farms.

Many Ontario Farms Increasing Production

We in Canada have not had that same length of time or experience, particularly on these prairies, that has been the experience of the men in the old country. In Ontario, however, many farms have been made to produce in recent years much greater crops than they ever produced before, even when they had that pristine fertility following the clearing of the land from forest. It is quite evident that in Canada, too, in some parts, at least, we need not anticipate any serious depletion of soil fertility if we are careful to follow the methods that are calculated to give us the best results. It is undoubtedly true, however, that on the prairies many of our farms, in fact, I think I am safe in saying, *the majority of the farms, are not producing to-day the crops that they did twenty-five or thirty years ago.* I can well remember the district of Winnipeg that number of years ago, when crops seemed to have been much better than they have been in the last six or eight years. The reasons for this are various; probably the most common being the abundance of weeds. The ability of the farmer, under present cultural or crop producing conditions, to keep his farm free from weeds seems to be very small, due, no doubt, judging by our experience, to the practice of unsatisfactory, or ill-advised, or of very poorly executed or carried out cultural methods. A further evident defect is the lack of moisture conservation power in our land. We suffer in this country periodically from drought, but the farmer who has utilized proper methods in the preparation of his fields for moisture conservation has a good crop. Now, that may sound slightly exaggerated, when moisture conditions are bad or when there has been practically no rain, but my observation during the past ten years goes to show that it is absolutely correct. Moisture may be conserved, however, in a very large portion of our soils, under even the most adverse conditions. In 1914, we had in the western part of these prairies a very serious drought, there being little precipitation throughout that district. The situation was so serious that I was delegated by the Department of Agriculture, at Ottawa, to investigate conditions, and to make a report as to what measures might be taken, not only to alleviate the situation, but to prepare against a repetition of crop failure, if possible, under similar conditions in the future. I went through the drought area, and spent some weeks visiting farm after farm, discussing with the individual farmers the situation and observing it for myself. In every part of Saskatchewan that I visited, and it was chiefly in that province that I made my observations, in practically every town you could find good crops here and there, not crops due to local showers or to any peculiarity of the local land area, but due to some special treatment of the field in question by the owner. Some of those fields would yield, I should judge, from 10 to 12 bushels in some cases, and others from 25 to 30 bushels per acre. In 1914, a crop of 10 to 12 bushels was a godsend and 20 to 25 bushels was a miracle in those districts, yet those very conditions existed, proving that, if the right cultural methods were followed, at least a fair crop under most adverse conditions might be anticipated. This was proven again by the fact that over the fence, or across the road, exactly similar soil, so far as one could judge by the most careful examination, had no crop at all. This made me more certain than ever that crop production, and with it soil conservation, depended upon the man rather than upon the land. True, weather conditions and soil have a good deal to do with it, but absolutely certain it is that the farmer has quite as much if not more.

Limiting Crop Factors

The factors that seem to be militating against crop production on these prairies, and that are responsible for the accusation that is being made now and again that the crop-producing power of our land is decreasing, are:—

(*a*) Weeds, which are the principal factor in some districts in lessening crop production;

(*b*) Faulty cultural methods, which are an important factor in all areas and the principal factor in certain areas, because the cultural methods just suited to crop production under conditions as they exist there are not known;

(*c*) Loss of the moisture content of the soil, which is due, in some measure, to faulty cultural methods, in some measure also to the physical condition of the soil due to bad cropping methods in past years;

(*d*) Low fibre content, which results, as we all know, in more or less blowing, even in the eastern part of the prairies, and even in this province.

These four factors, it seems to me, are the ones which are responsible for the accusation that our prairie lands are losing their fertility. Admitting these premises, as I feel we all do, the next step is to decide what must be done not only to correct the tendencies in these directions but to restore our soil to a virgin state:—

(*a*) Freedom from weeds. As you know, the prairie, when first broken, is practically free from weeds.

(*b*) To maintain or increase the moisture-holding quality of the soil. The prairie, broken for the first time, having as it then has, all the humus and fibre, if it is not broken down in edges, has wonderful moisture-holding powers, as most of you know. I intend to enlarge upon it. One could give many examples of new breaking holding moisture for many months after that moisture has been precipitated.

(*c*) Abundant fibre content. If we have the land free from weeds, if we have it capable of holding moisture in abundance, and if we have it full of fibre, roots and stems, as it was in the beginning, then we have it capable of producing just as great crops, and, if properly handled after that, of maintaining that power of production indefinitely, and, possibly, in the case of certain soils, increasing it, for there is absolutely no reason why we cannot increase the fertility of many soils on the prairies just as has been done and is being done in the East and in the older countries.

Introduction of Hoed Crops Necessary

The operating of our farms or soils to bring about the conditions I have mentioned—freedom from weeds, increased moisture-holding power, and increased fibre content,—involves, it has seemed to me and to those of our staff with whom I have been associated in a study of this matter, the introduction of some hoed crops into our rotations on the prairies. This does not necessarily mean hand hoeing—I see some here who have had practical experience on the prairie, and they will agree that to undertake to hoe over a whole section in a few years would be quite a contract—but hand hoeing is not the only method of hoeing on the prairies, any more than it is elsewhere. It is quite possible, as I have seen in the last few days in Manitoba, to cultivate hoed crops with little work and to keep them practically free from weeds. The summer-fallow must continue to a greater or less extent, according to the district or province in which we are operating. Then we must more closely adhere to right methods of performing the different operations. I am not exaggerating one particle when I say that carelessness in cultural methods has been undoubtedly the greatest curse to this country. It takes precedence over any other evil that is found upon the prairie. To this carelessness are due, in very large measure, the presence of weeds in such abundance, the poor moisture conservation and the low fibre content. Further, to increase the fibre, we must have the uses of grasses and clovers to a greater extent than has been practised in the past. This states the case very briefly. I feel that we are all agreed that the factors making for decreased crop production power are those I have mentioned. Any one of them might be considered from different angles, but I will leave that phase of it and go into what might be considered the practical side of the work that we have undertaken.

Conference on Cropping Experiments

Nine years ago last March, after some years of consideration previously and after discussions with our then Experimental Farm staff, before I was director of farms and when I was more closely in touch even than I was later, I called a meeting at Regina of our then superintendents, Mr. Fairfield, Mr. Hutton, Mr. Mackay, Mr. Munro, Mr. Everest, and Mr. Murray. After three or four days spent in threshing these problems out we outlined some systems of work to be undertaken on our Experimental Farms. These we immediately proceeded to put into effect. In the summer of 1911, we started on the Experimental Farms at Lethbridge, Lacombe, Indian Head, Scott, Rosthern, and Brandon lines of experimental work which included experiments in crop rotation and in cultural methods. The results from experimental work are of value and interest to the average farmer only when they are translated into dollars and cents. You tell a man that it is a good thing for the conservation of fertility in the soil to grow a certain crop or to do a thing in a certain way, and he immediately wants to know what is going to happen to his purse while he is carrying out that work. He might have ideal conditions for fertility conservation but very poor conditions for the conservation of the life of the owner and his stock, so I shall try, in what I have to say in connection with these experiments, to put it into dollars and cents, and let the results speak in that way.

Fixed Values for Comparison

To make the figures comparable, fixed values were put on all crops at that time. Slight changes have been made recently in some cases, but for seven or eight years fixed values were used in order to compare one year with another, without going back to see what the value of wheat was in 1911 or in 1917. We also fixed values of the different work. A man's work was valued at so much a year in 1911, and was kept at that price, though we may have had to pay more.

The cultural work we undertook—because we have to undertake the cultural as well as the rotation—includes some twenty different lines. Some of them it has been found possible to eliminate; and from some of them we did not gain any information worth while and they have been dropped. Most of them are still under operation at most of these farms, and from a good many of them we are gaining valuable knowledge, which in a short time, I think, will be made public, and the best practices be generally adopted by the farmers of this country. The information is, of course, being used to a limited extent at present, through the teaching of our different superintendents. On the whole, we have in cultural experiments some 2,500 or 3,000 plots at the different farms mentioned, about 500 at each farm. These cover the whole field of cultural methods and problems, so far as were known at that time, that confronted the prairie farmer. The first thing considered, and I will try to arrange these in order of priority on the farm of the farmer, was the breaking. We had on certain of our farms some virgin soil, and we studied different methods of breaking. Breaking has been studied for many years, but it has never been definitely settled as to which is the best method of doing it. I have travelled over these prairies for twenty odd years, and with as many different speakers purporting to be practical men and really practical men on these prairies, but very seldom did I find two men in succession advocating the same method of breaking or the same treatment, so it was necessary to study that problem as well as the others. It was decided that the experiment should be to determine the best time and method of breaking virgin prairie sod and to determine the advisability of cropping the land the year it is broken. The results, very briefly, of some of these breaking experiments were:—

Cropping on Spring Breaking

Green feed, flax and wheat are compared, sown on spring breaking; wheat is sown on deep spring breaking and also on land broken shallow and backset.

Results at Lethbridge—The best results were obtained by shallow breaking early in June and backsetting in September. Sowing wheat, flax or green feed on land broken the same spring did not prove a good practice.

Results at Scott—Deep spring ploughing yielded, on the average, over one bushel per acre more than shallow breaking and backsetting. Backsetting is not considered an advantage, however, where the native vegetation is destroyed by ploughing once.

Results at Rosthern—Deep ploughing in June gave the highest yields, while shallow ploughing in June and backsetting in September gave the next highest.

The great problems, undoubtedly, are moisture—conservation of the moisture-holding power of the land, weed freedom and increased fibre content, along with humus, which goes with moisture conservation. This experiment was, therefore, along the line of moisture conservation, because the chief object in breaking is to uproot the soil and then hold the moisture that falls that season.

The next consideration was depth of ploughing, which is again a matter of moisture conservation. We tried that work at all the farms in the system, and the results, while in some cases slightly contradictory, are, on the whole, very satisfactory. I might just interpolate here that the summaries I am giving you cover from seven to nine years, and cover the whole six farms, so that they are fairly comprehensive as to time and as to area. The results achieved at the different farms are not always the same, as might be anticipated, seeing that the precipitation in Manitoba is considerably greater than in Saskatchewan or Alberta. The results were kept separately and compared or collated later.

Depth of Ploughing (Summer-fallow)

Outline—Summer-fallow was ploughed at depths varying from three to eight inches, subsoiling four inches, beneath a ploughed furrow of from five to eight inches.

Results at Lethbridge—Results were rather contradictory, but, in general, shallow ploughing gave the lowest yield. It is considered that subsoiling certainly has no value as a means of overcoming drought.

Results at Lacombe—Best results were obtained from ploughing six to eight inches deep. We had a large number of plots there. Subsoiling increased the yields. Subsoiling increased the moisture-conserving power of the land, but I do not think enough to pay for the subsoiling.

Results at Scott—Results are more or less contradictory, but the practice of subsoiling has proved beneficial.

Results at Rosthern—Best results obtained from ploughing five inches deep. It is considered that although subsoiling may give higher yields, the extra cost outweighs the extra returns.

Results at Indian Head—Averages for nine years show that ploughing at least six inches and down to eight inches gives the best results without subsoiling, while the best results of all were obtained by ploughing eight inches and subsoiling four inches.

Results at Brandon—No consistent difference has been observed from various depths of ploughing. The yield of wheat has been lessened by subsoiling.

Depth of Ploughing (Breaking Sod)

Outline—Three plots were ploughed, 3, 4 and 5 inches deep, in the fall, and another plot 3 inches deep in the spring, and sown with wheat.

Results at Lethbridge, Lacombe, and Brandon—Deeper ploughing gave a slight increase in wheat and a more marked increase in oats sown the year following on the wheat stubble.

Results at Rosthern—No results noted.

Results at Indian Head—Results here were exactly opposite to those at Lethbridge and Lacombe, the shallow ploughing giving the best results.

Summer-fallow Treatment (Once vs. Twice Ploughing)

Outline—Three plots were ploughed at varying depths in June, packed and cultivated. Three other plots were ploughed at the same depths in June, cultivated, ploughed again in September, and harrowed.

Results at Brandon—No advantage was shown from ploughing twice.

Results at Indian Head—Ploughing twice proved unnecessary, where first ploughing was from six to eight inches deep.

Results at Scott—Ploughing twice gave smaller yields than ploughing once, besides being an added expense. In semi-arid areas, ploughing twice tends to dry out the soil,

Results at Lacombe—Better yields given by ploughing once. Double ploughing gave a heavier crop of straw, which did not stand up very well.

Results at Lethbridge—Ploughing twice gave slightly larger yields than ploughing once, but at an added expense. When ploughed land was left unharrowed in the fall, there was a loss of over one bushel per acre.

Summer-fallow Treatment (Depth of Single Ploughing)

Outline—Plots were ploughed 4, 6 and 8 inches deep, packed if necessary and practicable, and cultivated if necessary.

Results at Brandon—Deep ploughing gave best results.

Results at Indian Head—Six inches gave best results, 8 inches the next best, and 4 inches the poorest.

Results at Scott and Lethbridge—Increased yield as depth of ploughing increased.

Lacombe—Wheat sown on fallow gave highest yields for shallow ploughing, but the oats sown on stubble the second year reversed this result.

Summer-Fallow Treatment (Pasture vs. Bare Fallow)

Outline—One plot was ploughed five inches in June, seeded to rape or other green forage crop, and pastured off. This was compared with bare fallow, receiving the same preparatory treatment.

Results—Pasturing off reduced yield at all five farms.

Summer-fallow Treatment (Dates of Ploughing)

Outline—Three plots were ploughed on May 15, June 15, and July 15; they received the same subsequent treatment, and resulting crops were compared for two years.

Results at Brandon and Indian Head—July ploughing gave lower yields than either May or June. May ploughing showed no advantage over June.

Results at Rosthern—June ploughing gave higher yields than either May or July.

Results at Scott and Lacombe—Earliest ploughing gave highest returns, but in the case of May ploughing, subsequent cultivation was necessary through the summer.

Results at Lethbridge—June ploughing gave the highest yields.

Stubble Treatment for Wheat (Fall vs. Spring Ploughing. Use of Packer)

Outline—Some plots were ploughed in the spring and other plots in the fall. Some fall ploughed plots were subsurface packed immediately after ploughing. Some spring ploughed plots were also packed. Seeding was done at the same time on all plots.

Results at Lethbridge—Spring ploughing gave higher yields than fall ploughing, as stubble holds the snow. No increase was noted from use of packer on fall ploughing, but increased yield followed the packing of spring ploughing.

Results at Lacombe—Fall ploughing gave higher yields than spring ploughing, but packing showed same results as at Lethbridge.

Results at Scott—Same results as at Lethbridge, with the exception that packing increased yields both in spring and fall ploughing.

ploughing.

Results at Rosthern—Fall ploughing gave higher yields than spring

Results at Indian Head—Same results as at Rosthern. Packing increased yield on spring as well as on fall ploughing.

Outline—On one plot the stubble was burnt and wheat seeded at once.

Results at Brandon.—Inconclusive.

Stubble Treatment for Wheat (Spring Burning)

Outline—On one plot the stubble was burnt and wheat seeded at once. Results on this plot were compared with those on plots on which stubble was burned in the fall and then ploughed, and ordinary fall ploughing.

Results at Brandon—Inconclusive.

Results at Indian Head—No advantage was shown by burning stubble.

Results at Rosthern—It is considered that burning stubble is conducive to soil drifting.

Results at Scott—Same remark as Rosthern. Stubbling in has given best results at this station.

Results at Lacombe and Lethbridge—Burning stubble has reduced yields.

Stubble Treatment for Wheat (Discing after Harvest)

Outline—Plots disced after cutting and ploughed either fall or spring are compared with plots which received no discing.

Results at Lethbridge—Discing before fall ploughing gave increased yields.

Results at Lacombe—Main advantage from discing after harvest seems to be in keeping weeds in check.

Results at Scott—Discing at cutting time has given increased yields, both with spring and fall ploughing.

Results at Indian Head—No appreciable difference noted.

Results at Brandon—Inconclusive.

Seeding to Grass and Clover (With and without Nurse Crop)

Outline—Five plots are seeded after various crops with nurse crops and five similar plots without nurse crops.

Results at Lethbridge—Show that seeding alone should be advocated.

Results at Lacombe.—Seeding with nurse crop is recommended for Lacombe, but not for drier districts.

Results at Scott—Seeding alone gave higher yields, but it is considered that the increased yield does not warrant dispensing with the nurse crop. Rosthern and Brandon had similar results.

Results at Indian Head—Inconclusive.

Seeding to Grass and Clover (Preparatory Crops for Seeding down)

Outline—Plots are seeded to grass and clovers after summer-fallow, hoed crop, first-year wheat, manured and unmanured, and second-year grain.

Results at all the Farms—After summer-fallow gave best returns, after corn next.

Breaking Sod from Cultivated Grasses

Outline—Comparisons are made between ploughing early and treating as summer-fallow, ploughing in July and backsetting in September, and fall ploughing.

Results at Lethbridge and Lacombe—Best results were obtained by ploughing early and treating as summer-fallow, next by ploughing in July and backsetting in September; poorest yields from fall ploughing.

Results at Scott—Same as Lethbridge and Lacombe, but it is considered that the increase in grain is not sufficient to warrant the loss of the hay crop. Similar results were observed at Indian Head and Brandon.

Barnyard Manure

Barnyard manure was the next consideration. A point I have not touched on yet is the importance of introducing animal industry much more extensively on these prairies. Keeping live stock can be done profitably and easily on the prairies. At one time this was scoffed at, but to-day it is admitted by all who know anything about it that it can be done, and done fairly easily, and it certainly can be done profitably. Whether it be horses, beef cattle, dairy cattle, sheep or swine, there is no line of animal industry—and poultry might be added—which cannot be carried on on the prairie profitably and readily. Another point is that the manure has a great value, although methods of application, judging by our results at the different farms, are difficult to arrive at. In Manitoba the application of barnyard manure on a rotation including no hoed crop has not proven very satisfactory, but where we have corn or roots or potatoes it is highly satisfactory. Indeed, in the other provinces, where corn does not do quite so well, we have found it possible to apply manure satisfactorily in connection with summer-fallow in some cases, and in other cases we have applied it on the surface as a preventive of soil drifting with satisfactory results. While the immediate returns have, with the exception of those rotations including hoed crop, not proven profitable; that is to say, they have not paid during the year the manure was applied—in value for the manure and for the cost of applying it—they have, however, paid something, as a rule, and they have certainly left the field in better condition for future crops, so that the farmer who hesitates, or who claims that his manure might just as well be in a pile in the coulee, so far as any appreciable or noticeable effects are concerned in its use on the land, is making a serious mistake. Effects are immediate in many cases, are certainly immediate if the manure is properly applied, and are lasting. Of course, one must consider the weed problem, and great care is required. We have done a great deal in connection with the application of manure, and expect to get out a bulletin in the near future dealing with it. The results of the experiments were as follows:

Outline—Barnyard manure applied in spring and fall, ploughed in or used as top dressing, compared with plots not manured.

Results at Brandon—Not sufficient information to base conclusions. Apparently the best method is to apply manure in the fall and plough in.

Results at Indian Head—In almost all cases the plots to which manure was applied gave higher yields than plots not manured, although with some crops the average yields for crops sown on second-year stubble manured were lower than on plots not manured. The results with different kinds of manure and from different dates of application were rather indefinite, but the application of green manure (cut straw) in winter seemed to give good results in many cases.

Results at Rosthern—Application of manure to land to be summer-fallowed, ploughing under and packing gave an average yield of five bushels of wheat per acre more than plain summer-fallow. Manure applied to land other than summer-fallow leaves the ground too open.

Results at Scott—Rotted manure applied as top dressing in spring has given no advantage over no manure. Ploughing under either in fall or spring gave increased yields over top dressing. In districts of scanty precipitation it is considered advisable to plough manure under, except when used to lessen soil drifting.

Results at Lacombe—Application of manure gave increased yields over no manure, and the best results from application of manure were obtained when manure was turned under very shortly after being applied.

Results at Lethbridge—Application of barnyard manure increased the root crop, on an average, three tons per acre over no manure. Top dressing in winter and ploughing under in spring gave higher yields of cereals than application in spring before ploughing.

Green Manuring

We also carried on work in green manuring, but it was not satisfactory. We experimented with peas, vetches and other crops, clover sod, etc., and, while we found they increased the fibre and no doubt did increase the humus, and evidently increased the water-holding power of the soil also, the immediate results were not satisfactory although some crops gave better results than others. For instance, peas were found to be more useful than vetches in some cases, and clover was found best of all.

Outline—Peas and tares compared with barnyard manure and bare summer-fallow, the peas and tares being ploughed under.

Results at Lethbridge—Results show little to be gained from green manuring, as the plots on which peas and tares were ploughed under gave an average of 3½ bushels per acre less than bare summer-fallow and 5½ bushels per acre less than summer-fallow on which barnyard manure had been applied.

Results at Lacombe—Two plots out of three gave less yields under green manuring than bare summer-fallow, while the third gave slightly higher yields. Barnyard manure gave higher returns than either. The only advantage noted from green manuring was that it tends to keep fibre in the soil.

Results at Scott—Ploughing under gave slightly higher returns than fallowed land, but not so high as barnyard manure. Peas ploughed under gave better returns than tares. Green manuring is not considered a sound practice in the semi-arid regions, where all moisture must be conserved.

Results at Rosthern—Ploughing under either green peas or vetches gave lower yields than plain summer-fallow.

Results at Indian Head—Ploughing under peas or tares gave slightly higher yields than bare summer-fallow, but not so high as summer-fallow to which barnyard manure had been applied.

Commercial Fertilizers

We also tried commercial fertilizers, which are practically unknown on these prairies, and I doubt if they will ever be very useful in the Prairie Provinces, at least, not in this generation. The abundant fertility in our soil, if satisfactory cultural methods are followed, will be maintained for many years to come. Another important point in connection with the use of commercial fertilizer is, we have such a low rainfall here, that the availability of these is very seriously impaired. They might be useful under irrigation, but under average dry farming conditions it is never certain when a return will be secured from the fertilizer applied.

Outline—Nitrate of soda, superphosphate and muriate of potash, alone and in combination, were applied to plots, and these compared with unfertilized plots and plots fertilized with barnyard manure. Oats, hay, corn and wheat are grown in each combination.

Results at Lethbridge—The best results with oats were obtained from unfertilized plots. Hay gave highest yields on land broken from clover sod. Barnyard manure gave best results with corn. It is impossible to make comparisons of the various fertilizers, as results with different crops are so conflicting. It would appear, however, that the soil here is not so much in need of fertilizing as of humus.

Results at Rosthern—Indefinite; the presence of alkali patches in the area used for this experiment upset all calculations.

Results at Indian Head—Nitrate of soda alone gave increased yields of oats and corn over unfertilized plots. Superphosphate alone gave increased yields with all crops. Muriate of potash alone gave decreased yields with all crops except corn. The only combination of commercial fertilizers that gave higher yields in all cases than the check plot was nitrate of soda 160 pounds, superphosphate 300 pounds, and muriate of potash 100 pounds per acre. This combination gave an average higher yield than any other fertilized or unfertilized plot in the experiment. Barnyard manure gave, on the average, lower yields than the commercial fertilizer with oats and corn but slightly higher with wheat.

Results at Brandon—No appreciable increase in yield was noted from the use of fertilizers.

Experimental Crop Rotations

Having studied the cultural methods and the experiments to determine what were the best practices to follow in connection with handling different crops, we then turned our attention to the establishing of sequence of crops, or crop rotations, on the prairies. No one knew what was the best arrangement of crops. The common practice in Saskatchewan was summer-fallow—wheat—wheat or, if a man needed a few oats, summer-fallow—wheat—oats, or, if conditions were particularly favourable, he might possibly have summer-fallow—wheat—wheat—oats, making it a four-year, but, generally speaking, it was a three-year rotation. A three-year rotation or succession of crops was the one policy of the farmer. In Manitoba the three-year rotation was spun out one year longer in most cases, and is yet, I think; that is, summer-fallow—wheat—wheat—oats or barley, or sometimes the barley took the place of one of the wheat crops. This system had the effect, as might be expected, of very rapidly depleting the soil of fibre, and allowing the surface to blow away during periods of high winds. The soil would pile up around the fence, in the coulees or around the house, sometimes to the depth of seven or eight feet; many other injurious results also followed. We undertook some 22 different rotations on the prairie, the length of which was anywhere from one year, that is, wheat continuously (at Lethbridge) up to ten years. There was one case at Lethbridge where it was alfalfa continuously. We had a two-year rotation also at Lethbridge. There were some three-year rotations, one

of which was used at all the farms. We had two four-year and one five-year rotation in Manitoba; one or other six-year rotations on all the farms, there being some seven different six-year rotations in the whole system; we had one seven-year rotation at Lacombe; two eight-year rotations, one at Indian Head, Rosthern and Scott and the other at Brandon; two nine-year rotations at all the farms except Brandon; and three ten-year rotations.

Monetary Returns from Rotations

I might discuss the different crops in some of these rotations. As in the cultural methods, we had to fix values both for the returns and for the cost of operating, in order to make them comparable all over the prairies and from year to year. The one-year rotation was all wheat. Strange to say it has given, so far, a pretty satisfactory return in profit per acre; the average in eight years has been $6.77 (at the old fixed price of 1½ cents a pound) over and above all cost of production and rental as well. The two-year return, which is also at Lethbridge, gave a fairly satisfactory profit of about $3.68. That was wheat—summer-fallow—wheat—summer-fallow. That might be expected to give, under average conditions, a good yield, but on account of the barren years, it very materially reduced the profit per acre from the farm.

Three-year Rotation

The three-year rotation, summer-fallow—wheat—wheat, one that is very commonly practised all over the prairies, was tried out at all the farms except at Brandon, and the returns were uniformly fairly good, so far as straight profits are concerned. At Indian Head it averaged about $5 per acre, including the year when there was no crop. In other words, $5 an acre for three years means that each wheat year had to have at least $7.50 profit, the fact of the matter being that wheat after summer-fallow gave $10 to $12, and the wheat after wheat a much smaller profit; the summer-fallow, of course, was a dead loss, and this must be deducted from the profit. At Rosthern this rotation gave a profit of nearly $7, at Scott $3.72, at Lacombe $4.77, and at Lethbridge $5.54. The returns at Scott in good years were satisfactory, in dry years very unsatisfactory.

Four-Year Rotation

In Brandon we tried out a four-year rotation, wheat—wheat—oats—summer-fallow, on two sets of plots; in one case we applied manure, in the other we did not. The manure applied did not pay for itself the year applied, and has not shown that it has paid for itself yet, although it has been in effect five years, it is, however, rather too soon to conclude what will be the ultimate result. The profits are very low in both cases, about $2 with manure and about $3 without. While the manure increased the crop, the manure had to be paid for, which took away a lot of the profit. Of course, if the manure could not otherwise be sold it would be lost, so that the farmer may be said to have gained something for himself by the sale of his manure. He had to haul it anyway.

Five- and Six-Year Rotations

A five-year rotation tried at Brandon, was wheat—wheat—corn manured—oats or barley seeded down—hay ploughed up in midsummer. This and the next rotation have proved very satisfactory, particularly the next one, a six-year rotation, wheat—wheat—oats or barley seeded down—hay—pasture ploughed up in midsummer—corn manured. That rotation has proved a most excellent one from many standpoints. It is a real six-year rotation. It does away with summer-fallow entirely, corn taking its place, and the results have been very satisfactory indeed, in so far as uniformly good crops are concerned. I visited this field on Monday (July 12) and can say that the wheat after corn is, I think, the best crop on the farm, in very many cases better than any wheat after summer-fallow. Corn is not a highly profitable crop as a rule; we do not get much out of it, but it invariably pays for itself. The crop harvested and stored, valued at fixed values of $3 a ton, more

than pays for the cost of producing, whereas with bare summer-fallow, such as is necessary to eradicate weeds and conserve moisture, the whole of the summer's work would be lost, while the returns from the crop after the corn is just as good as after the summer-fallow, in fact a little better in some cases. This point is, I think, worthy of consideration at this meeting, and it is worth a tremendous lot to the province. Since the inception of that work up here many farmers in this province have undertaken the production of corn, and in every case practically similar results have been secured. This proves, in my opinion, that there is very little or no need for summer-fallow in this province (Manitoba), because a crop can be grown which will utilize the manure—which is another advantage corn has over other crops, it will utilize manure profitably—conserve the moisture, free the land from weeds and increase the fibre. The inclusion of that crop brings out, or rather builds up, along all the lines we have mentioned, increases humus, conserves moisture, increases fertility by adding humus, utilizes manure and promotes freedom from weeds. That would seem to be a solution to the question here. Where corn can be grown in this province mangels certainly can, because, further north, where it is a little colder and frost comes a little earlier, mangels and turnips do quite as well as they do anywhere else, and they have the same effect upon the soil, or practically the same effect. I have seen in this province, since we started this work, crops of corn that would run 12 to 15 tons to the acre. We have had crops at Brandon that went considerable over 12 tons; I do not know that it ever passed 15 tons, but large average crops and big crops can be produced and are produced in this province. We ripened our own seed last year at Brandon, and it looks as if we shall ripen it again this year. It has had an excellent start. Other six-year rotations were tried at Brandon, with very satisfactory results.

Another six-year rotation was tried at Indian Head, Rosthern and Scott, namely, summer-fallow—wheat—wheat—oats—hay—pasture. One little difficulty arose in seeding down. When three years elapses after summer-fallow before seeding down difficulty is often experienced. Indian Head station reports that this rotation is not satisfactory, as a catch of hay is seldom secured on account of seeding down so far from fallow. At the Scott station this has proved the most satisfactory rotation. There has been no damage from soil drifting and good catches of grass every year.

The two other six-year rotations are in Lacombe. We have not nearly as much trouble in seeding down at Lacombe, which makes it very easy to increase the fibre and retain the moisture in that district. We had also a six-year rotation at Lethbridge, being summer-fallow—wheat—coarse grain (manured in fall)—summer-fallow—peas and oats for hay—barley or oats, two summer-fallows in six years. The profit from the six years on the average was $3.68, that is, over a period of eight years and includes the very dry year of 1914 and last year, which, I suppose, was the next driest.

Seven-year Rotation

A seven-year rotation is followed at Lacombe, with very satisfactory results, giving as high as $9 an acre profit. Hoed crop—wheat—oats—summer-fallow—barley—hay—pasture. We have at Lacombe also a six-year rotation, which has proved highly satisfactory, and which we are using on the fields there as our standard rotation. It is hay—pasture (manured)—pasture—green feed—oats and barley seeded down. There is no wheat. Lacombe is the centre of a great livestock district; this rotation is highly suitable for requirements there, and we have followed it for some eight years now. It is having the effect of supplying us with an abundance of feed, increasing the crop-producing power of the farm, and of cleaning it from weeds. It is, so far as the effect upon the farm is concerned, a perfect rotation, and there are some hundreds of acres under it. It is not a perfect rotation, so far as the wheat exporter or elevator man is concerned, but it is the rotation that suits

us and therefore, should suit many of the farmers in that district. These rotations, as I have shown, have given profits of from \$3 to \$8 or \$9 an acre. At Lethbridge we have a couple of rotations under irrigation. These, compared with the dry land rotations, make the above profits look very meagre, as the net profit per acre, over and above every item of cost, is somewhere in the neighbourhood of \$45 each year. We cannot, of course, introduce water all over these prairies, so we have to take things as we get them and leave irrigation rotations to those who live in an area where irrigation is available.

The whole question of crop rotations and cultural methods is, as you see, covered, more or less, in the field of work we have undertaken, and we have now the results of eight years of operation. At Brandon we have results for a longer period, because Mr. Murray and myself planned out some work there in 1908 when Mr. Murray came. The results at Brandon are, therefore, older, and the rotations better established, and we know pretty well the crop rotation best suited to this province, or at least to that portion of the province comparable to Brandon. The work is one which must be taken up, I feel, by every college and illustration station, as well as by the experimental farms. This might be called the pioneer of experimental work. The results secured may not be final; in fact, I should be astonished if they were in connection with most of the work, but they give us something to base our criticisms on, something to build on or study when preparing for new work. They are based on experiments from every province, over a good period of time.

I trust that when time is afforded to discuss this matter that you will not hesitate to criticize as severely as you wish, particularly as by this means many new suggestions and valuable information may be secured from the technical and practical men present.

The Chairman: Dr. Grisdale, you spoke of the destruction of stubble by burning. Would the burning have any compensating service in destroying weeds?

Dr. Grisdale: Slightly, but not of material benefit. It passes over so quickly, it does not seem to hurt the seed.

The Chairman: Did the green manuring experiments include sweet clover at all?

Dr. Grisdale: No, we did not include it in the experiments, but we are growing it on the farms and it may take the place of the corn. We did not include sunflower either.

Professor Bedford: What were the results of experiments as to discing in the crop?

Dr. Grisdale: I think it was very satisfactory in many cases. I do not think we have any experiments in discing; a lot of experiments in discing stubble in the spring or fall proved satisfactory.

The Chairman: Have you the yield each year, extending over the eight or ten years, of single crop? Has there been a decrease latterly over the yield for the first few years?

Mr. Fairfield: It would depend entirely on the rainfall; so far as we have seen, there has been no falling down of the fertility of the land yet if there is sufficient moisture.

The Chairman: Since there is no evident reduction in the yield of crop because there is plenty of substance in the soil, is there any apparent reduction of the fibre in the soil?

Mr. Fairfield: Of this particular field we can notice no particular change. We do know, however, that there is a change in the neighbourhood, shown, chiefly, by the soil drifting. We do not have soil drifting in our plot work, because there are always fields of stubble and different crops to protect the plots. We do know that in the neighbourhood the soil-drifting problem is increasing from year to year, so that it must be the result of the lessening of the soil fibre—the change in the physical texture of the soil.

The Choice of Crops and Soil Productiveness

BY

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EMINENT agriculturists state that exclusive grain farming in the older sections of Western Canada is fast reaching a point of diminishing returns. Through the inroads of weeds, soil drifting and consequent increasing difficulties in the conservation of moisture, soil productiveness (the ability of the soil to produce crops) and profitable crop yields cannot be maintained.

Agricultural history is merely repeating itself in Western Canada. One-crop systems of farming, whether practised in Asiatic, European or American agriculture, cannot continue indefinitely, and sooner or later must encounter serious cropping handicaps and make recourse to radical modifications imperative.

Losses from Weeds

Rough estimates of the annual losses from weeds alone are from 75 to 100 million dollars for the three Prairie Provinces. During the three crop years of 1917-19 losses from soil drifting ranged from very little in some sections to complete failures in others. Losses in soil fertility are even greater. The drier the conditions, other things being equal, the heavier are the losses from blowing.

Some of the underlying causes of these conditions are:

1. The prevalent single cropping system of farming which results—

(*a*) In multiplication and distribution of weeds. Their effect upon the soil and crops needs no discussion here.

(*b*) In rapid reduction of organic matter in the soil. With the organic matter of the soil reduced, and the ability of the soil to absorb and conserve moisture impaired, the soil particles are released and free to move with the winds.

2. The effects of blowing soil are:—

(*a*) Growing crops are injured by the rapid moving of sharp particles of soil, or are entirely destroyed by being blown out of or covered by the soil.

(*b*) The soil is injured through the loss of much of its surface or more productive portion.

(*c*) Seeds are distributed from field to field with the moving soil, thus materially aggravating the weed problem.

The means at man's disposal for most effectively correcting these conditions is in a proper choice of crops, which must be somewhat different from that which obtains to-day. Less than two per cent of the total crop acreage in Western Canada is mixed hay and legumes. More fodder, pasture and hoed crops must be employed, otherwise the existing evils, that menace crop yields and soil productiveness due to single cropping methods, instead of being removed, will become more acute.

Most grain growers appreciate the need of a wider choice of crops and the use of live stock, but are unprepared to adopt such measures. They point to the difficulty of obtaining catches of grasses and clovers, of obtaining suitable legumes, and of using manures profitably and satisfactorily, and, finally, to the heavy initial outlay for stock, buildings, fences, etc.

Change of Methods Necessary

The time is ripe, undoubtedly, for a change of methods; but I am not sure that it would be wise to advocate, at this time, radical changes in our systems of farming, because I believe that the farmers of Western Canada are moving in the desired direction, perhaps as rapidly as they can. The farmers are doing pretty nearly what economic conditions dictate, and will modify their cropping methods as soon as conditions enable them to adjust their farm organization advantageously. It is, furthermore, true that with land cheap, and all the materials that are used in producing crops, including money, expensive, the path of least resistance, and if successful, most profitable, although very uncertain, is along extensive rather than intensive lines.

We must, therefore, keep these facts clearly in mind when advocating means to alleviate present conditions, if we would successfully steer farmers through a rather important transitory stage in the evolution of a permanent agriculture in Western Canada.

To-day we are essentially grain-growers, because these crops are cheaply grown and readily marketed. Of these, wheat, oats, barley and flax are most widely grown. Unfortunately, however, these make similar demands and have similar effects upon the soil. Our choice must be wider, and include other crops that will assist in removing the bad results of a one-type-crop system of farming, such as grass crops, legume crops, winter rye, etc. This choice should also involve a systematic rotation of crops, which, indeed, is as important as a judicious choice. The farmers will, however, adopt new methods and systems of cropping only as the crops involved are readily adapted to present systems, and can give a profitable return either in direct financial returns or indirectly through benefit to the crop or soil.

Advantages of Winter Rye

Winter rye is a winter annual, and, while similar to the cereal crops widely used at present, is one that can be used as a pasture and hay crop and will, at the same time, lessen the effects of both soil drifting and weeds. It may be seeded at intervals, either during the summer or fall, and used as a pasture crop both in fall and spring. As it grows it covers, and protects the soil from drifting throughout the fall, winter and spring months. It holds bad weeds at bay, and, when pastured or cut for fodder, prevents them from seeding. In addition, the summer seedings of winter rye, especially, add large amounts of fibre to the soil through the extensive developments of roots. This important fact is often overlooked.

Winter rye may also be seeded on the leeward side of summer-fallow to serve as a windbreak the following spring, when the "blow" is severest; also in 30-foot strips at right angles to the prevailing winds, at intervals of about 10 rods across the field. Six rather important functions are thus rendered by winter rye:—

(1) Pasture crop for fall and spring;

(2) Hay crop in spring;

(3) Protective crop against ground sweeps and soil blowing;

(4) Trap crop to catch the soil that blows;

(5) Trap crop for snow;

(6) When used as summer pasture it functions as a fibre crop.

Rye is not only a suitable crop for our conditions of soil and climate, being both drought and frost hardy, but, most important of all, it can be readily adjusted to our present evolutionary system of farming. It is a winter annual, a very vigorous growing crop, starts early in the spring, and gives pasture and hay of a very palatable quality.

Corn and sunflowers may be used similarly to winter rye. Seeded in strips on the fallow in July they grow quickly and afford much pasture in the fall. What remains of the stalks will hold snow during the winter and break the ground blow the following spring, when wheat may be seeded as though the stalks were not present. The land among the corn or sunflowers will be packed quite firmly by pasturing; when sown it will turn up coarse and lumpy, and will therefore blow less readily. The strips of soil between will also be less affected by blowing. Either of these crops may be sown as a substitute or a partial substitute for the fallow, especially on soils subject to drifting, thus providing much pasturage or silo material. Sunflowers give splendid promise as a silage crop, for the maintenance of live stock.

Drought Hardiness of Sweet Clover

Sweet clover may be utilized in quite the same manner as the aforementioned crops. It has the advantage, however, of being a legume. It may best be seeded in 30 to 36-inch rows. Seeded in July on the summer-fallow, it grows rapidly, and produces a growth of 8 to 15 inches by fall. This growth is capable of protecting the soil during the winter and early spring, while a quick new growth performs a similar function during the early summer. Wheat is sown between the strips of sweet clover. Sweet clover may be cut in July to supply much needed fodder in the dry areas of Western Canada. Its drought hardiness, in contrast with most clovers, give it a commanding position.

It may be that none of these crops will offer a permanent solution to the problems of soil drifting and weeds, but they will lessen their effects and, what is equally important, farmers are enabled to grow slowly into live stock farming.

A permanent solution of these problems is in the systematic use of grasses and legumes in conjunction with the crops that have just been discussed. Of the grasses, awnless brome and western rye are the best for the dry areas. Brome grass having a very extensive creeping root system, will renew wasted soil fibre quickly. Both of these grasses are quite drought hardy, provide pasture, and make into good hay. Much breeding work, however, remains to be done in producing even better grasses than either of these. Sweet clover promises much, not only as a forage plant, but as a soil improver. It has the advantage over brome grass in that it is a legume, and therefore, leaves the soil richer in nitrogen than does brome grass, although the latter produces more root fibre. The use of grass crops adds humus, or root fibre, to the soil, improves the soil, as a result of its dense root system, and provides forage for stock from which manure for further improving the soil may be obtained.

Summarizing the above thoughts, they are:—

(1) Evolutionary methods of cropping will be required to solve present problems of soil productiveness, such as weeds and soil drifting.

(2) Winter rye, sweet clover and sunflowers crops will alleviate problems in soil productiveness.

(3) Awnless brome grass, western rye grass and timothy, in conjunction with the three aforementioned crops, will develop a more safe and permanent agriculture, in which weeds and soil drifting will be definitely controlled.

(4) In the drier sections grain farming will continue the main enterprise, but with the use of the above crops, agriculture will be established through the development of live stock farming.

(5) Summer-fallow will be modified in practice in the drier areas, although the underlying principle of moisture conservation, upon which the fallow was founded, must be maintained.

(6) The silo will be used in conjunction with winter rye, sweet clover, sunflowers and other fodder crops yet to be discovered, thus making the best use of these crops, in assisting the farmer to maintain the requisite number of live stock.

There are areas in southeastern Alberta and southwestern Saskatchewan, incapable of being irrigated, upon which it would seem unwise to try to continue to grow crops. With limited rainfall, and prevailing conditions of soil drifting and weeds, the task of applying the methods outlined in this paper is insuperable, and entirely impracticable. I will go further and state that, in my opinion, no method of cropping is possible and profitable under these extreme conditions of climate. There is only one recourse, namely, reclamation. Extensive reclamation experiments should be inaugurated at once, whereby these large tracts may be economically returned to grass for grazing. Our governments will have to face this problem at an early date, and thus conserve much human material that will otherwise soon migrate.

Cropping Systems for Drought Areas

BY

PROF. JOHN BRACKEN

President, Manitoba Agricultural College

IT has been a pleasure to me to be here and to listen to the very valuable papers that have been presented. It is the first time I have ever had the privilege of attending a session of the Conservation Commission, and if the others have been like this, I am sure they must have been of very great service to Canada. I was pleased yesterday to hear the Deputy Head of the Commission make a statement before the Rotary Club, to the effect that the function of the Commission was not to develop our resources at the expense of the future, nor to retard present development for the sake of the future, but rather to develop our resources to the utmost without wasting them.

Conservation of Land a Public Duty

That is a motto that many of our public institutions might adopt. There are no resources that lend themselves to development and conservation at the same time to the same extent as our agricultural resources; and while this is a function of the Commission, I think it well to emphasize the fact that, if left to individual initiative, the problem of development and the problem of conservation tend to dissociate themselves. A farmer on the Portage plains or in the Qu'Appelle valley, or in the Moosejaw district, finds it profitable, under favourable conditions, to grow wheat. As an individual he finds it returns him an immediate profit, but there is no getting away from the fact that he is growing that wheat at the expense of the soil—that, while he individually may make a profit, the state is the loser. In other words, in the way that our society is organized at the present time it is not necessarily the business of the individual to be concerned about the future of the state; it is rather the business of the state to conserve its own future. Hence we realize the great need for encouraging such organizations as that holding this conference to-day.

Coming to my subject "Cropping Systems for Drought Areas," I would like to define the terms used, in order that you may not misunderstand anything I may say. A drought area may be defined in any one of a number of ways. It may apply (1) to an area of low average precipitation; (2) to regions having wide variations from average precipitation; (3) to climates where there is a wide departure from the normal time at which rain usually comes; (4) to zones having a high evaporation, or (5) to areas where warm winds are common. In Western Canada, at the eastern boundary of Manitoba, the precipitation is nearly 22 inches, but it steadily decreases, westward, until the boundary between Alberta and Saskatchewan is reached. The precipitation in the vicinity of Medicine Hat is 13 inches, and west of that point it increases slowly but gradually until the Rocky mountains are reached where, in parts of the high foothills, there is 30 inches or more.

Variations in Precipitation

It seems fairly well established that the variations, both with respect to amount and monthly distributions of rainfall, are greater in the western provinces than in Manitoba, and there is some evidence that these variations increase gradually from eastern Manitoba to western Alberta.

Professor Hopkins, in his analysis of the precipitation data for portions of Western Canada, has pointed out that the evaporation is very much higher in some sections of southern Alberta than it is in the northern part.

A drought area may be one that is subjected to hot winds, consequently the figures for precipitation are of little use unless with them is considered the amount of moisture sucked up by the hot winds. In southern Alberta a warm wind, known as the Chinook, sometimes passes over the land; when the crop is two or three feet high, it may be seriously injured as a result.

The drought area of the western provinces, or rather the dryest area, may be divided roughly into three parts; namely, (1) the Chinook area in southern Alberta, and southwestern Saskatchewan, perhaps bounded on the north rather closely by the South Saskatchewan river and on the east and west by the line of 15 inches rainfall; (2) the open prairie part north of the Chinook belt and south of the park belt, and (3) the park belt. I shall not refer to cropping systems in the park belt, but will confine myself to a discussion of cropping systems in the other areas mentioned.

Cropping Systems

Cropping systems for drought areas imply a knowledge of two things, (1) the crops that are most suitable, and (2) the system, or rotation, or order, of cropping that is best. I will only touch upon a few of the fundamental factors:

The cash crops are the cereals and flax—wheat in the south, oats and barley in the north, flax on breaking and heavy soil, and rye on light or drifting soil.

The best annual hay and pasture crops are the cereals and millet, and, for some classes of stock, rape; among biennials, winter rye and sweet clover, and among perennials western rye grass, brome grass and alfalfa.

Among the fodder crops, corn in the south and on the worn soils, and sunflowers in the south and also in the north, because they require less heat and yield much more than corn.

Among the silage crops there are three, corn, sunflower, and oats. Any other crop that grows may be put in a silo, but few make as good silage as those I have mentioned; they will all make feed, and all help to carry animals over a time of drought, such as we have had in many parts during the last three or four years.

The crops adapted to the conservation of the soil may be divided into three groups. The first includes those that use the least moisture and which may to a certain degree replace the summer-fallow. These are corn and other intertilled crops, such as rape and potatoes, or cereals sown in triple rows with a wide space between each three rows. A second group of crops, including the perennial grasses, adds fibre to the soil, and a third, the legumes, not only adds organic matter, but nitrogen, to the soil.

Time for Breaking Land

In the early years men came in to the dry region, broke up land and sowed flax or oats, or some other crop on it the year the breaking was done. This resulted in frequent failures, and the practice has almost ceased; some new people coming in still try it, with the same result. The practice now it to break land one year and sow it the next; this gives an opportunity to get some of one year's precipitation into the land and conserve it there for the use of the next year's crop. In our tests at Saskatchewan we found that every week's delay in breaking after June 10 decreased the yield one bushel per acre; in other words, if a piece of land was broken on June 10 it might yield 30 bushels to the acre; if an adjoining piece were broken in October it would yield 15 bushels; or, in a year that June breaking would give 15 bushels, spring breaking will fail to produce a crop.

In preparing stubble land for sowing, in the early years before weeds got established on the land, the common practice was to stubble in the crop. The

longer the practice was carried on, however, the more weeds got into the land, and as a result farmers have had to change their plans. Under dry conditions, where there is very little precipitation in the fall, spring ploughing has been found to give better results than fall ploughing. In the Red River valley fall ploughing is the common rule and generally the best practice.

Varying Effects of Summer-fallow

The summer-fallow, with all its faults, has been and still is the most important farm practice in the dry region. It has many advantages, and has probably been the chief cause of the development of the dry lands in western Saskatchewan and southern Alberta. It stores and conserves moisture, kills weeds and makes plant food available in the soil one year for the use of next year's crop; it also has an economic advantage, in that it enables a man to spread his work over a longer season. In that region men could not possibly prepare all the land for sowing in fall and spring.

But the fallow has two serious disadvantages, and these might well occupy the best thought of this conference for a few minutes. The first is that the fallow causes a rapid decrease of organic matter; the second is that it causes a very rapid loss of the most valuable plant food constituent in the soil, namely, nitrogen. I shall refer to these again, but let me say, in passing, that in the southern portion of this dry area the farmers are summer-fallowing, some of them every other year. As one goes north, where the evaporation is a little less, they summer-fallow once in three years, and further north even less frequent.

I want to discuss briefly two questions. The first is, where is this system leading, and the second, what are we going to do about it?

The summer-fallow has been an aid, and is still an aid, in the rapid and profitable development of our dry farms; but its inevitable results point in the direction of reduced returns, soil depletion and land ruin. Evidence of the truthfulness of this statement is in the thousands of acres that have been lost through soil drifting, as a direct result of intensive cultivation and the one-crop system of farming. It decreases returns. The figures quoted by Dr. F. T. Shutt, Dominion Chemist, on tests of soil taken from Portage la Prairie and Indian Head, two of the best soil types in Western Canada, show that after 23 years—14 crops and nine summer-fallows—one-third of the organic matter and one-third of the nitrogen in the top soil has been lost.

What is to be done about it? All we can do is to get possession of the facts regarding our climate, our soil and what is happening here, and adapt our system of farming to the conditions that obtain.

Moisture the Limiting Factor in Crop Yields

What are the facts? I would like to emphasize a few of these to you, and then try to answer this question. The first essential thing to note is, that moisture is the limiting factor in crop yields. We cannot get away from that. So long as moisture limits the yield of the crop nothing else will increase it. A chain is as strong as its weakest link. There are links in the problem of crop production. One of those links is moisture; another, organic matter; another, plant food. The weakest link is moisture, and it will not strengthen that chain any if we strengthen some other link. We have to strengthen the weak ones first, and as we strengthen the weak ones we strengthen the whole.

The wealth of a dry country is determined not by the amount of land, not even by the amount of water that falls on the land, nor by the amount of water that falls on the land and is stored there and used by growing crops. As a matter of fact the water that is used in producing straw, under the present system of farming, is largely wasted. We must build up a system that will utilize that by-product, which at the present time is using over one-half of the moisture that we store and conserve in the soil.

Necessity for Diversity of Crops

Another fact is this, that the precipitation varies very largely from year to year and from season to season, and because of that we shall have to diversify our cropping system. It has been pointed out, and should be emphasized here, that Western Canada is, first and foremost, a cereal-producing country; occasionally the precipitation comes in the early part of the season, with the result that cereals partly or wholly fail. By diversifying our cropping system we can reduce this risk. I would like to take time to discuss the point further, but time forbids. I will say, however, that because of some rain we had at Saskatoon last year, we have now (August) certain crops which are not a failure, and because of the lack of rain this year our cereal crops are a partial failure; in addition, if we have any late summer rains, our corn, sunflowers, potatoes and sweet clover and millet will make a good crop.

Legumes to Utilize Nitrogen

Among the limiting factors of crop production moisture is the first. The second thing that will limit the crop yield in dry regions is organic matter. The third factor that will limit the yield is nitrogen. There are seventeen million pounds of nitrogen in the air over every acre. If we can find and grow a legume crop suitable to our conditions, we can draw upon that seventeen million pounds and grow fifty-bushel crops every year for a million years, so far as nitrogen is concerned, and if we do not grow legumes, we cannot use that store of fertility. The fourth factor that will limit the yield on the normal soils of this area will be plant food in the form of phosphorus.

Irrigation Where Possible

In attempting to answer this question, I would say that the first thing that should be done in Western Canada—I am speaking now particularly of the western part of our dry area—is to make use of the water that is at present lost in our streams, by the greater development of irrigation. Water is the measure of the wealth of that region, and the water that runs away in streams to Hudson bay is a measure of our lost opportunities. Another point is that we must help to bring about a classification of our lands. Some of the speakers here have said that in their opinion some of these dry lands are not suited to the system that is being followed. Many will agree with them. There are some that do not. In my opinion it is altogether a matter of adjustment. I do not think that a man can make a living on a quarter section or even on a half section there; but I am quite sure he can make a living if he gets enough land and adapts his system of farming to the rainfall conditions that exist. This is a problem in farm management. It is a problem that the Government, through its experiment stations, can help to solve. In parts of western Nebraska men left the land a few years ago, but they went back again after some years, and, instead of trying to make a living on a quarter or a half section, they took up larger areas. In some parts of that state they have two or three sections, they are making money and have happy and contented families. What they have done there we can do here, if we apply ourselves to the problem.

Community Pastures

In some parts of our dry region we shall need to use waste land for pasture, the large areas for community pasture and the smaller areas for private pastures. Let me also add, in passing, that we should manage this pasture land more intelligently than we have ever done before. Pasturing this land late in the fall results in its almost complete failure for pasture purposes in just a few years.

In the dry region we shall need to have one field in perennial crops. We have heard of the difficulty of growing grasses. There are difficulties in growing grasses in that region, and they cannot get a good stand every year, but, having

put a field under grass, a man should not break it up until he gets another established. If he cannot get it established one year he may the next and if not the next year, the year following. He must have one year in fallow or a fallow substitute. Many of the latter have been mentioned; corn is good if planted far apart in wide rows; potato land gives a fair return; cereals sown in triple rows leaving a space of three feet between each set is being tried. There is immediate need of knowing the most suitable cash crops to grow on the fallow, as that is the place to grow the cash crop. For each soil type there is one cash crop more suitable than any other. We are fast gaining information to show us which is the best under the different conditions. Until the land starts to blow, or until it shows some evidence of decreasing yield, a second cash crop may be used in the rotation in these areas, but sooner or later it will be found that a second cash crop will not pay.

We would then have (1) a fallow with different substitutes on certain parts of it; (2) the cash crop; (3) under favourable conditions, a second cash crop and a legume crop, or the perennial hay field, or both.

Live Stock to Use By-products

We need also to adjust the size of the farm to the rainfall. We should endeavour to make live stock pay expenses, by utilizing the waste products and the by-products of the present grain system and by utilizing the forage crops necessary to maintain soil productiveness. We do not think that a live stock system of farming should be built up there without having a cash crop in it. We should get away from some of the bad theories of the past and look at facts with unprejudiced eyes.

Then we should take a lesson from the pages of history. There are years in that part of Western Canada when in spite of anything that a man may do, cereal crops will fail. We might as well accept the truth, because it is a fact, and we must know the truth if we are to plan to meet those conditions. We can only meet them by saving something from the fat years for use in the lean years. That was done thousands of years ago and we can do it again. Joseph had one bushel out of seven put by as a reserve. Some may say that we have not had fat years, but we do have fat years. We require to save feed; to save seed; to save straw; to save money, and one time I found an experimental station in Colorado actually and successfully advocating the use of what they call a reserve silo. A man puts up one silo, which is enough to feed his stock. Then he starts another, and, when they get enough forage in a good year, fills the second one and keeps it for use in a short season. The silage will keep, and when it is thus saved a man has something to carry his stock over a period of drought; consequently, instead of sacrificing his herd, and having to start over again with a big expenditure, he is able to carry on.

Advantages and Profits of Systematic Crop Rotations

BY

W. C. McKillican

Superintendent, Experimental Farm, Brandon, Man.

IN the absence of Mr. McKillican through illness this summary of his paper was read by Mr. F. H. Reed, Assistant Superintendent of the Brandon Experimental Farm. Mr. Read read:—

"The chief advantages of systematic crop rotation may be briefly stated as follows:—

"1. Rotation systematizes the farm work. There is a definite portion of land prepared for each kind of crop for each year and the areas of the crops grown remain constant. Farm work is more economically and efficiently conducted as a result.

"2. In a systematic rotation each crop or season is handled in such a manner and is of such a nature as to be the proper preparation for the crop which follows. This results in increased average yields and greater efficiency.

"3. Control of weeds, plant diseases and insects is facilitated by crop rotation, as frequent change of type of crop interferes with their multiplication and all good rotations provide regular recurrent times for a clean-up.

"4. Any benefits from soil enriching crops or soil improving methods are distributed uniformly over a whole farm by a good rotation.

"5. Frequent crop change avoids the soil depletion incident to constant one-crop farming.

"A good rotation should include at least one of each of the following:—

"1. Cash crops, *i.e.,* crops readily convertible into cash and such as are likely to be reasonably sure of success and profit in the territory covered.

"2. Cleaning and moisture storing crop or fallow, a regularly recurring period in the rotation which provides suitable opportunity for weed eradication and the accumulation of soil moisture.

"3. Forage crop. All the best crop rotations assume live stock as an integral part of the farm system, and forage crops must be grown to nourish the stock. Where conditions make live stock raising impossible, any permanent rotation must provide a substitute in the form of green manures.

"4. Leguminous crop. No permanent system of agriculture has been built up anywhere that does not include in its rotation at least one of the nitrogen-storing groups of plants.

"The rotations under test at Brandon include the following types:—

"1. Straight grain growing.

"2. Grain growing plus hay crop.

"3. Grain growing plus hay and hoed crops.

"The first type give better results than unsystematized grain growing, but are greatly surpassed in profit, freedom from weeds, freedom from soil drifting and general conditions of the soil by both the others. A typical rotation of the second type surpasses the first by 44 per cent in net profits in the average results of five years. A typical rotation of the third group excels the first by 75 per cent.

"Some of the most striking facts in regard to crop sequence from crop rotation work are:—

"1. The great value of corn as a preparation for grain crops.

"The seeding of grasses and clovers should follow corn or summer-fallow. The more intervening grain crops there are, the greater the chance of failure.

"3. Wheat is the most profitable crop after fallow or corn.

"4. Coarse grains are more profitable than wheat as second crop after fallow or corn.

"5. Wheat makes a satisfactory nurse crop for grasses.

"6. Field roots are much less effective than corn as a preparatory crop for grain, and sunflowers somewhat less effective, though better than roots."

Speaking on his own behalf, Mr. Reed continued as follows:

Systematic rotations properly adapted to local conditions of soil, climate and labour are the foundation of all permanent agriculture. If a good system of crop rotations had been introduced into our prairie farming methods at the beginning we should not now have our most serious problems of weed control and soil drifting. Some of our farmers who have not adopted proper crop rotations are commencing to find that their system of farming is not permanent, but subject to very frequent change, as soil drifting is annually taking away their most fertile land or bringing them new land from their neighbours. It is a hackneyed phrase to call our farmers "soil miners," but it applies in two ways. Too many farmers, like miners, have for years been taking everything possible out of the soil and putting nothing back. It has been said that, in mining, for every profitable mine there are ninety-nine holes in the ground, and in many of our older districts, where drifting has been very bad during the last few years, farmers are commencing to find that they may end up with not a profitable mine but a hole in the ground.

One of the principal objections which farmers raise to adopting rotation systems is that it necessitates extra fencing, and the cost of a good fence is high. Where necessary, cheaper, temporary or movable fences may be used, but poor fences are a menace to live stock and should not be considered. Good fences do cost time, labour and money, but the cost is very much less than the extra profits from a good systematic rotation.

Dr. Grisdale: The importance of introducing rotations into our cropping methods in the west has been dwelt upon, and I but emphasize the good results we have had in some of our rotations, at least in different farms on different parts of the prairie. Everything that Mr. McKillican says in favour of a rotation is correct, as far as I know from my experience of twenty-one years in conducting this kind of work in connection with experimental and other farms, from observation and from all I can read. Now admitted, as the best kind of evidence would seem to indicate, that these facts are true, it would seem to be little short of idiocy for a farming population to neglect or longer to delay putting into effect some suitable rotation on their farms. I say *suitable.* Nearly all farmers are following some kind of a rotation or system, because the majority are more or less systematic. Unfortunately, too many farmers have a bad scheme, bad rotation. What we want to get introduced on every farm is a good rotation, and what is a good rotation on one farm is not necessarily the best on another. That we appreciate this, is shown by the fact that we have on trial on our experimental farms in the west some twenty odd rotations. Of the rotation in the west, I think the five-year rotation that uses corn, is the one that might best be introduced in Manitoba anywhere south of Neepawa, possibly even further north; and from the eastern boundary to the western. I have seen it tried in almost all parts of that district in Manitoba, and it is satisfactory, possibly not that exact rotation but the general succession of crops which are included in it. The one weakness is that the seeding goes a little too far beyond summer-

fallow, or comes a little too slowly after the hoed crop, or substitute for summer-fallow. This is a difficulty, no doubt, but it is just questionable if we would be making any improvement by putting it closer up to the hoed crop. It would mean the losing of some grain-producing powers of the rotation and necessitate bare fallow or another hoed crop of some kind in the operation of the rotation. At Brandon, three times out of four we have had a catch. I am familiar with the results there year by year excepting last year, and only once in five or six have we had any trouble at all, and never until last year did we have a complete failure. This year, it does not look very promising. We can, if the catch fails, use something to offset the failure. It will not be so satisfactory, but it will give a crop of hay or pasture with a little more work and with a little less satisfactory results; nevertheless, it would keep the rotation going, and, as I said, since we are safe in saying that for three-fourths of the time, if not more, it will be absolutely all right, I think it is the best thing to do. I think with Mr. McKillican that that rotation should not change; Mr. Murray, with whom that rotation started, is also of the same opinion. That old rotation, slightly modified, but practically the same, has been used there for eleven or twelve years. When a rotation has been tried out that long, and when the two men who have had most to do with it are agreed that it is probably the best thing that could be devised, there can be no question of it and we would be ill-advised to think of changing.

It is important, in spite of the progress that has been made in this country towards the introduction of live stock, to produce nevertheless large quantities of grain. The cash crop is very important. It is not enough to have a fairly assured revenue from live stock; if we are going to make farming profitable, we must have cash crops, and the natural cash crop of this country is wheat, or grain, and in any rotation that is likely to be satisfactory, you must have some good cash crop surely coming on. We have provided for this in practically every rotation that is under way on the experimental system in the west, with the exception of one or two at Lacombe, where what might be called strictly cash crops hardly enter. We grow oats and barley, but do not expect to sell the grain; in fact, no more grain is produced on the main rotation than is sufficient to carry the stock. There is no cash crop in that rotation. It is essentially for the live stock man, and might be advisedly followed by farmers where live stock is the principal object in view—the keeping of the animals in good shape and getting all you can out of them and the keeping of as many as possible on a given area. Now if you will review mentally or when the opportunity occurs go over the rotations previously discussed*, you will notice that every one provides a fairly good proportion of cash crops. They are not all equally satisfactory, and should be considered individually

Maintaining the farm in a condition free from weeds and keeping the moisture-holding power of the land as high as possible are of primary importance. Mr. Hopkins has said that moisture was the most important. A rotation that is satisfactory makes preparations both by getting the soil into right shape and, by cultural methods, to hold that moisture as well as it possibly can be held, by storing all the moisture available. Land in bad shape, unless it lies in a very special way, will shed a lot of moisture; land in the right shape will absorb it, and, while it may escape in spite of everything you may do, the more it receives the longer it takes to get away; hence a good rotation makes every preparation for the reception and retention of all possible moisture. That is another point we have attempted to follow in the various rotations. Rotation J, which was mentioned by myself yesterday* (and later by Professor Harrison,†) is in use on all our farms, namely, fallow—wheat—wheat—

* Experimental Crop Rotations, p. 20.
† Place of Grass in Rotation, p. 66.

oats seeded down—fallow preparatory to grain—three crops of grain seeded down. In that rotation there is the remoteness in seeding down from the fallow, but, I believe, it is a little difficult to improve upon. Mr. Harrison's suggestion of breaking the sod in July or late June as a sort of supplementary fallow is probably the nearest to an improvement, but that rotation, with a slight modification as suggested by Professor Harrison, is a highly satisfactory rotation. We have found some modification more necessary in J than in the rotation at Brandon, although it is astonishing the number of times we have succeeded in seeding down in that rotation. We thought when we fixed upon it at Brandon it was going to be troublesome, if indeed, it would be at all successful in the seeding down, but in the eight years it has been in effect, I think we have only missed three of getting a decent catch, so that it is not an unsatisfactory rotation. At Indian Head, particularly, it has been quite satisfactory; at Scott and Rosthern, where it is also in operation, we cannot judge, because two or three times we have been hailed out and the whole crop has been spoiled. At Scott it was not satisfactory one year, but since we have every year one field that has been seeded down, we know just exactly how each year affects the rotation. The rotations where the seeding down is done right after summer-fallow have this advantage: where a man has live stock on a large scale and needs more coarse grains, he can get along on a rotation, better, I would say, where the seeding down is done immediately after the summer-fallow. Seeding down can be done best, of course, without a nurse crop, but that is entirely too extravagant. Since the chances of failure are probably only 10 per cent or less, it is no use considering seeding down without a nurse crop immediately after fallow, so that sequence should be entirely eliminated in any crop rotation.

Another advantage in crop rotation is the conservation of the fertility and the maintenance, if not the increasing, of the fibre content of the soil. By the very fact of these grasses (and in some cases clover, because in this five-year rotation clover rather than pure grass, is used), being seeded down, the fibre content is increased and the water-holding power of the soil is certainly improved. In the five-year rotation at Brandon, wheat has for probably six or seven years been better than anywhere else. That is the best crop we have, which is due very largely to the fact that the land carried this fibre-producing crop preparatory to the wheat, and that it was gradually increasing in organic matter so that the amount of moisture it could hold is greater now than it was when that rotation was incepted. We have no careful analysis of the soil to show that this is the case, but everything points to it being better now than it used to be. Similar land adjoining or nearby does not seem to hold the moisture nearly so well. It is a fairly fine grain soil, more retentive than sand, but not more retentive than the adjoining fields. We think this must be due to the increase in organic matter; so this rotation, you see, not only prepares wisely for the grain crop but increases the good qualities of the soil so far as fertility is concerned and so far as moisture is concerned.

Moisture, fibre and fertility are the three important things in the crop-producing problem of the west, and of these three moisture is the greatest, and I think we have made every preparation there. I think this is the most important change or step in progression to be made on these prairies, the introduction of a better rotation. We have a rotation now but it is a bad one. What we want to do is to adopt a better one and that is what we are endeavouring to secure at this conservation meeting. If we could get that change, if we could get the farmers in this country thinking along that line, the changing from that three-year rotation in the west or four-year in the eastern part of these prairies, including a summer-fallow in each case, and also get them considering

all the possibilities of a hoed or cultivated crop, we should have done more for agriculture in these provinces than any other convention or meeting of men has ever done in the history of the prairie.

Prof. E. S. Hopkins (Olds, Alta.): I would like to say a few words on crop rotation and crop systems. The farmers in certain portions of the country are undoubtedly in a very serious financial condition, and unless something is done, in the way of experimental work or otherwise, to help solve their difficulties, they are going to be ruined. Farming is a business, and if a man puts several thousand dollars into a farm, he wants to know where he is going to get out. Under the agreement of sale system of purchasing land in the west, if a person makes a deposit on the land, and the crop fails, he loses out. If, for the dry areas of Alberta and Saskatchewan and to some extent in Manitoba, we have no scheme evolved to enable these men to farm that land properly, it means enormous loss. We certainly need far more extensive experimental work than we have yet done. Extension work is very good, and teaching work is very good, but we cannot teach and we cannot extend what we do not know, and we do not know how to handle land in those sections profitably. We have some idea, but we do not know, and I wish to emphasize the urgent need of more experimental work along the line of crop rotation and crop production, in order that we may obtain information that will enable farmers to make more money on their farms.

The Chairman: Even if and when we do know enough, how is that going to move the ordinary farmer, who is not in the way of knowing as we are? Supposing one hundred men or a thousand men in any one of these provinces did know what was necessary to meet present conditions, what about the hundred thousand other farmers who are not in the way of getting, or even having, the knowledge, or are without a background of experience to guide them in applying it? There is a big gap, the bridging over of which we must be continually thinking of, so that the average man will be able, willing, and have the desire to put the best knowledge into practice on his farm. More experimental work is necessary, as also illustration farms.

Mr. Marnoch: It has been said that in certain areas there is not any chance of getting irrigation, and men are moving out; it was also indicated that the remaining men might be taken care of by making the holdings more extensive. Before encouraging these men to go into live stock at all, we will require to find out about the waters under the earth, if water is not available on the surface, for the sustenance of the live stock. We had a geological survey made of a considerable portion of southern Alberta, and found an area of about 500 square miles underlain with waters flowing over sandstone into the Milk river. Since that discovery, some 17 artesian wells have been put down. If a similar geological survey has not been made in Saskatchewan, and if water is not readily available near the surface by ordinary well-drilling, it might be well, as a preliminary step, to have a geological survey now. From our experience of the past this suggestion is worth following up.

It is evidently running in all our minds that something should be done about these men, to talk with them and find out their attitude of mind. There are some amongst them who are more or less content to take things as they are, but there are others who should be encouraged, and who have sufficient energy to get out and do something for themselves, if the way were indicated to them. Some of these men have established themselves, and do not want to leave, and it would be necessary to find which among them would best succeed with live stock holdings. These are men who would make most excellent citizens with just a little help and guidance during these trying years. Others would have to be encouraged and ways opened up for them, and, possibly, be guided to some other place to earn a livelihood. Whether, indeed, some of them should stay on a

farm at all, or whether farms can be found for them in other regions and how that could be financed, because it would need some financing and some finding of suitable land for them, where their efforts might meet with better success, are matters which are entitled to the earnest consideration of his conference.

The Chairman: In this matter of further experimental work it has been suggested, and I want to propose, that a committee be appointed to consider this question, whether all the requirements are now covered, and, if not, to suggest how they could be covered and how the work now being done could be co-ordinated so as to bring the best results in each place. I have pleasure in proposing that a committee, composed of Dr. Grisdale, Messrs. Bracken, McKillican, Hopkins, Fairfield, Cutler, and Nunnick, be appointed for that purpose with power to add to their number. Substantially, if it wants definite terms of reference, this paragraph that "Experimental work should be continued and co-ordinated on Government Experimental Farms, in trying out and comparing methods of applying knowledge, already possessed, to the practical operations of farming, in order to obtain the best economic results under varying conditions of soils, climate, markets, labour and other available resources," would be a general term of reference for the purposes of this committee. Dr. Grisdale will be convener of the committee and Mr. F. C. Nunnick its secretary.

Good Seed

BY

L. H. NEWMAN

Secretary, Canadian Seed Growers' Association

ALL who are interested in the welfare of Canada must appreciate the enormous value of the annual production of her crops, reaching, as it does, into the millions of dollars. While that production is enormous—something over 800 millions of bushels over all of Canada, including cereals and potatoes—approximately 8 per cent of it has to be set aside each year for seeding purposes. Approximately 65,000,000 bushels of seed grain alone is required to seed the areas devoted to those crops. We also require approximately 9,000,000 bushels of seed potatoes to plant the areas growing our potato crops. In other words, we require about 75,000 carloads, each containing 1,000 bushels; or a train, reaching from Winnipeg to Port Arthur, 500 miles long, every car containing 1,000 bushels.

The area devoted to these crops in Canada is approximately 41,000,000 acres, therefore, if, by any process of seed selection, seed improvement or better methods of farming, we could increase the productive power of that seed by one single bushel per acre, it would add approximately $80,000,000 to the wealth of the country in a single year. The seed question is, therefore, an exceedingly important one and one to which this conference, or any body of public spirited people, can well afford to devote some attention.

There are four main ways in which production may be increased: (1) by adding fertility directly to the soil; (2) by cultivating the land a little better and by following a better system of crop rotation; (3) by adopting suitable measures to protect our crops against the ravages of plant diseases and insects, and (4) by the more general use of seed of better breeding and of varieties more suited to the conditions where grown.

Planting Weed Seed

The need for greater attention to the seed used in Canada is everywhere apparent. Those who visit seed exhibitions, even where the finest grade of seed should be found, will recall the presence of impurities, and of mixtures of other varieties. A few years ago some interesting investigations were conducted by the Commission of Conservation and also by the Dominion Seed Branch. I will refer very briefly to the investigations of the Seed Branch only. Samples of seed were taken by special men directly from the grain drills at seeding time in this province (Manitoba)—146 samples of oats were taken, 60 of barley and 100 of wheat. Of the farmers from whom the samples of oats were taken, 62 did not know the name of the variety they were growing, 67 treated their oats to prevent smut and 79 did not. The average number of weed seeds was 369 and the largest number of weed seeds in any sample of oats was 2,153 per pound. Very few farmers knew the name of the variety of barley they were growing. In the case of this crop, as high as 9,968 weed seeds were found in a single pound, while in wheat 967 noxious weed seeds and 1,264 less harmful weed seeds were found in a single pound. Taking the average number of weed seeds in the case of the three crops mentioned, we found by sowing at the average rate that there would be sown on each square rod of land, 160 weed seeds in the case of oats, 32 in the case of barley and 44 in the case of wheat. I was impressed, two or three years ago, in passing

through Fort William, by the enormous amount of weed seeds carried from the western provinces to the terminal elevators at that point. I found that very often the dockage reaches as high as 18 per cent. In 1913, it averaged 18 per cent. I found that there was carried that year, from the prairies to the terminal elevators, 100,000 tons of dockage, that is, 100,000 tons were taken out in the form of weed seeds at the terminal elevators. The transportation of this seed would require 3,300 cars and, according to the rates prevailing then, would cost approximately $650,000 by way of transportation charges. This is only one of the phases that is considered in connection with the good seed problem.

Many agencies are seeking to bring about the more general use of good seed, such as experimental farms and agricultural colleges, various enterprises conducted by our agricultural extension services, field crop competitions, boys' and girls' clubs and contests, experimental unions, especially in Ontario, etc. We also have the Dominion Seed Branch conducting a very important work, and the work being carried on throughout Canada by the Canadian Seed Growers' Association.

Varieties Originated by Farmers

The isolation of superior strains of field crops is largely the work of experts at experimental stations or agricultural colleges. On the other hand, we must recognize the possibilities that lie within the reach of the ordinary farmer to isolate strains of superior worth. We have only to recall that some of our leading varieties were brought out by ordinary farmers. Red Fife wheat, for example, for many years the leading wheat in Canada, was originated by a farmer; Dawson's golden chaff wheat, an autumn wheat which has been the leading wheat in Ontario for many years, was originated by a farmer by the name of Dawson. We also have a potato called the Dooley, a selection out of the old Dooley variety which seems able to withstand dry conditions to an extent not enjoyed by many other varieties. This will be of interest to you people here who are concerned in dry farming. In roots, we have Corning's swede turnip, Moore's sugar mangel, and many other good strains, all valuable contributions and especially suitable to certain districts. The encouraging of individual farmers to carry on this work, and to look out for something better, is one of the functions of the Canadian Seed Growers' Association; a second function is that of supervising the propagation of improved strains and of making this seed more easily available to farmers than it has been in the past.

Full advantage should be taken of the growing tendency among farmers to study the crops they are growing. We have received at our office at Ottawa, during the past two or three years particularly, a great deal of correspondence from individual farmers who are studying crop growing, studying the application of improved principles, and who say they would like to have a little direction, with a view to helping them find something from among their own crops, if possible, which may mark an improvement over the varieties they are growing. Experience indicates that there is a certain adaptation going on all the while, and that some varieties become particularly suitable to certain conditions of soil. Farmers themselves are coming to feel that, and rather dislike throwing aside varieties which have done well with them but which, for various reasons, may have become impaired or mixed with some other sorts; or perhaps they may have found strains here and there which seemed to mark a starting point of a new and superior race. They are receiving encouragement and some assistance in endeavouring to establish and propagate these particular strains. While that may not be the first or the most important problem before us, it is one to which we can afford to devote some time. We appreciate the work of Seager Wheeler, George Dow and many others who have created a great deal of interest in the good-seed question. I find that good work done by an ordinary farmer creates

considerably more interest than if that same work were done at a Government institution. Farmers expect special work by a Government institution, but if another farmer does work of special merit, they feel they should be able to do the same thing.

Increasing the Supply of Registered Seed

The most pressing problem of the association is that of propagating efficiently and in a much larger way the good seed which is now available throughout Canada. The solution of this problem is being sought, first, by encouraging the organization of seed-growing centres; secondly, by improving marketing facilities; thirdly, by increasing the demand for good seed both in Canada and in the United States; fourthly, by encouraging private enterprise and initiative; fifthly, by making the production of registerable seed an entirely practical proposition for any farmer whose location and system of farming permits it. The organizing of seed centres is probably one of the best ways that this particular problem is going to be solved, especially in Eastern Canada. Seed centre work is not quite so important in the west as in some of the older provinces, where few farmers grow as much as a carload of grain. In the west there are many farmers who, either alone or with a neighbour, produce seed in carload lots. It is important in this work that seed be grown in considerable quantities, because we find that where seed is wanted is not usually around the district where the crop is best, but in districts where the farmers have to buy the seed, where they have had a failure or a partial failure and where seed is required in quantity. When farmers have to buy seed they usually wish to buy a little better seed than they have been using. The ordinary farmer, if he gets a reasonably good crop, is inclined, as a rule, to go on and use his own seed or get seed from his neighbour. There are a number of seed centres in Canada, and they are increasing. The seed centre idea consists simply in selecting areas which are known to be particularly suited to the production of seed of a high quality, and getting a number of farmers in those districts to grow seed in considerable quantities.

Prince Edward Island Growing Registered Seed

One of the most promising seed growing centres at present is in Prince Edward Island. It was realized that a good deal of excellent seed was being produced in Prince Edward Island and much seed grain was being shipped out of the island. While some of the best people there are not in favour of shipping grain off the island, they are not adverse to shipping seed grain if they get a sufficiently good price to enable them to buy back other feeds. After much discussion it was decided to undertake some definite work in the district of Kensington. A seed-cleaning machine was purchased, a warehouse was rented and arrangements were made to interest individual farmers of the district, with a view to placing in their hands for propagation some of the best registered Banner oats we could find. Last spring we distributed to forty-eight farmers in that district around 2,000 bushels of registered Banner oats, and it is hoped to have 50,000 bushels of registered Banner oats available for the trade next spring at that particular point. Manitoba is taking steps next week to start something of a similar nature. One of the big difficulties in the West, so far as the seed question is concerned, has been that of marketing. The problems of financing and of storing are particularly difficult. Many of our farmers are unable to hold their seed for any length of time and it goes into the elevator. Even if financially able to hold it, they lack facilities, and, unless they sell to the seed-house, they have not any very good way of conserving the seed for seed purposes, so it is largely lost for this purpose. Those farmers who are in a position and who have the inclination to grow a better class of seed than they have been growing in the past should be encouraged to keep it, and facilities should be

provided, if necessary, to assist them in keeping it. Financial arrangements, I am sure, could easily be made to enable them to keep it over until the seed purchasing season starts.

Export Demand for Northern-grown Seed

There is an excellent and growing demand for high-class northern-grown seed in the United States at the present time. Experience shows that northern-grown Canadian seed, in many cases, is likely to give rather better success in the United States than is seed grown in their own country. In Sweden, where great developments have been made, it was this idea of the superiority of northern-grown seed that started agricultural development. They hoped to develop seed propagation to a degree that would enable them to ship into Germany and France large quantities of seed grain. They have made excellent progress and have now a splendid organization.

Successful in Competitions

Last year, for the first time, an exhibition of seed grain was held in connection with the International Live Stock Exposition. Members of our association exhibited at that fair, and were able to carry off a large proportion of the prizes. With ninety-one entries in the open class for hard spring wheat, we took the first five prizes. Our men also took first prizes both in white and black oats and in barley. At the exhibition next December we are proposing to put up an exhibit to show something of what can be done in this northern country in the way of seed propagation, and we are hoping to have these exhibits represent a good many hundred thousand bushels of seed grain for sale. Last year private enterprises shipped, under difficulties, into the United States several thousand bushels of seed grain at very substantial prices. They are catering to that market and are expecting to develop it.

Up to about three years ago, the production of registerable seed met with certain difficulties, due largely to regulations. In the early years of our work we were not sure of our ground as regards principles and as regards human nature, therefore, we were restricted in our operations somewhat. Our growers were required to operate special seed plots and to make selections of heads for a plot each succeeding year. After a certain degree of superiority had been arrived at they could obtain registration for their product. That plan, we found, was very seriously limiting the amount of registerable seed produced in Canada, because the busy farmer cannot spend much time in special selection work. The regulations have been changed so that now any farmer, no matter where he lives, may purchase registered seed, grow it from year to year, have the growing crop inspected, and, if he can produce seed which is up to a certain specified standard as regards purity, quality and vitality, he can have the said seed registered. Some men cannot go on more than a year or two without getting into trouble and having to make a new beginning. Other men are able to continue for ten or twelve years without getting in a fresh supply.

Overcoming Impurities

When the seed begins to show signs of depreciation in purity or quality the grower may obtain a fresh supply from another grower or institution. If his difficulty consist chiefly in impurities getting in he may be able to rogue the impurities out, or he may make a selection of typical heads and use the seed obtained from these for a fresh start. Under certain circumstances he might find it advantageous to make what is known as "head-to-the-row" selection. We have an excellent illustration of how the latter plan works out in the case of one of our large growers in Saskatchewan. This grower had been growing Marquis wheat for some years, and still, in spite of continuous mass selection, found bearded heads and brown chaffed heads to arise fairly regularly. We had to refuse him registration for large quantities of wheat on account of these impurities on more than one occasion. We advised

him five years ago, to make a selection of what appeared to be typical Marquis wheat heads, and to sow the seed of each head by itself, carrying on the "separate culture" or head-row system, and to select one of those rows as a fresh starting point. He did this, and last year I saw over 500 acres of Marquis wheat on his own farm, all tracing back to a single row. Another grower further south had a beautiful crop all ripening at the same time, and uniform in quality, and which traced back to a single head propagated by the former grower.

Any farmer can grow registerable seed from year to year provided he sows registered seed, has the crop inspected and is able to harvest grain which is up to standard as regards purity, quality, and vitality. He does not need to carry on selection work from year to year, but the minute he gets into difficulty, the minute there is any sign of a falling-off in quality or purity, he can take three courses, namely, get a fresh supply, rogue or mass select, or, if circumstances warrant it, make a head row selection. The problem of producing pure seed in quantity is now comparatively simple; in fact, it seems a matter of poor business for any farmer who has reasonably clean land not to sow pure, registered seed, and have the crop inspected, with a view to taking a chance on weather and other conditions enabling him to come through.

Systematic Seed Supply Essential

Taking Canada as a whole, we feel there is need for a systematic survey of the whole country, in order that sufficient seed may be produced to meet our needs every year. I have been connected with this work now for nearly fifteen years, and there has never been a single year in all that time that Canada has not suffered in some part or parts to such an extent as to make the bringing in of large quantities of seed necessary. You are all familiar with the work of the Seed Purchasing Commission. You know something of the large amounts of seed they have had to purchase during the last few years. It seems to me, at this late date, it should not be necessary for that Commission, or for any individual or organization, to have to purchase seed of a lower standard than is required of registered seed; that is, they should be able to get seed in the quantity they wish, and of the variety and standard that is needed. There is a growing demand for a better class of seed, and if such seed could be bought in sufficient quantities, they would much rather buy it than seed of questionable quality. Last year large quantities of oats were purchased in Ontario. The farmers at that time got 80 cents a bushel, but the Commission would have preferred to pay a dollar a bushel for seed that could be recognized. We were able to get only a limited quantity of registerable seed, and by far the largest quantity came from Prince Edward Island.

The Seed Growers' Association is really comparable to the Live Stock Records office. We have not the staff to organize the work throughout the country. That is largely a matter for local effort, but it is gratifying to know that the different provinces are doing much more than they have done in the past in solving this important problem.

Dr. Charles Saunders: I am glad that this question of good seed has come before the conference. From the point of view of dry, very dry years, it is not the most important question, but is a question of very great importance, to which a deplorably small amount of attention has been devoted. I can never understand why it is that a farmer is willing to pay a very large price for a good animal, or large, relative to the value of an ordinary animal, when the same farmer very often will not care to pay a good price for good seed. We need good seed and we need good varieties. Something was said this morning about the varieties of winter rye. That is a very difficult problem, one to which we have not given as much attention on the experimental farms as I should have liked. Most so-called varieties of winter rye are very similar to each other, and

the strong tendency of winter rye to cross if plots are grown near together is another obstacle to the isolation of pure varieties, not an insuperable obstacle, of course.

I shall mention three ways in which I think seed improvement can be helped. The first requirement—I am not giving these in their order of importance—is that the farmers should think a little more—I will not say think more intelligently—on the problem itself, as I believe many do not think at all of the value of good seed, either good seed of the variety which they are using or good seed in the sense of seed of an appropriate variety. We are also apt to be led away by custom and to sow either what we sowed in previous years or a variety that is much talked about, without regard to whether it is the best for our conditions or not. The second point that may be worth mentioning is that many farmers lack cleaning facilities for their grain. That, in some instances, is the fault of the farmer; in other instances it can hardly be said to be so, and I have for many years thought that the establishment of central cleaning plants is absolutely essential to any proper extension of the growing of good seed grain, and would, incidentally, be very useful to some farmers themselves who were not too far away and who wished to take advantage of the central cleaning plant to clean up their own seed in a manner superior to what they could do themselves. The province of Quebec has a grain-cleaning plant not far from Montreal, which is managed by a man who has exceptionally high ideals in regard to purity in seed, and I can only wish that similar plants should be established all over Canada. One other point is, that our seed fairs in the past have, unintentionally, to a certain extent unconsciously, catered to the professional exhibitor of seed grain. Nine times out of ten he is an honest man, who cleans up a sample of his grain to the highest possible standard. Sometimes he may bleach his oats with sulphur fumes, or he may adopt other means that are, perhaps, objectionable, to bring the grain to a fine appearance, but in some cases, where honesty is lacking, he will use an old sample which has perhaps already won prizes in the previous year, and altogether he will use the fair as a means of making a few dollars in prize money. Seed fairs are not worth while on that basis. It is not in the interests of the country that any man should win a small prize for his seed grain so far as the prize itself is concerned. If it stimulates him to grow better grain, or stimulates someone else, very good, and no doubt it has that effect to a certain extent, but I think it not out of place, even in a convention of this kind, to make two suggestions in regard to seed fairs: First, that the sample of grain shall not be judged until after the germination shall be determined. This is a very simple matter; it merely means having the seed grain exhibits on hand two weeks before the opening of the fair. Second, and this suggestion is much more radical, more difficult to carry out and more important, perhaps—the seed grain exhibit should be representative of a quantity of seed for sale. This would require inspection on the farmer's premises, preferably, also, inspection of the standing crop. That could be managed, no doubt, under the Seed Growers' Association, or independently, the object in view being that when a farmer wins a prize at a seed fair he shall win it, not because of his showing an exceptionally good sack of grain, but because he has at home for sale a quantity of that grain which will be available for the enthusistic farmer who has attended the exhibition, and who has admired this sample and who wished to obtain some of the same variety, of the same quality, for his own use. I quite realize that any radical change in seed fairs is going to mean a radical increase in expenditure. I am not one of those geniuses who are capable of solving questions without increases in expenditure. The point is not, will it cost more; the point is, is it worth while, and I think the answer is yes.

Professor Bedford: I notice Mr. Newman mentions the fact that Banner oats are holding their own all over Canada, in spite of the fact that there is the new variety.

Mr. NEWMAN: There is no variety so universally grown at the present time as Banner. It seems peculiarly suited to a great variety of conditions, and it may be interesting to know that our very best strain of Banner, of which we have quite a number, was produced by Norman Dow, of Gilbert Plains, Man., who started in just twenty years ago. At Ottawa a few years ago that variety was compared with eight or ten others in ten-acre strips and it yielded the best by four bushels. One of our good strains of Banner was grown in Prince Edward Island by Mr. Waugh.

Professor BEDFORD: Have you found any great advantage in selecting the heaviest for seed, and fanning out the light? That is the practice I have followed.

Mr. NEWMAN: The strong, heavy oat seems to have a beneficial effect, for one year at least; that is why we try to have oats grown on good soil. The effect of soil in producing seed grain has not been sufficiently dealt with by most of our experts. We find if we can get oats grown on real good soil, the percentage of dockage is smallest and the next yield is likely to be better. That, perhaps, is one reason why registered oats have done so well in many cases. The continuous growing from year to year of those oats on good soil, we believe, has a beneficial effect.

Professor BEDFORD: There was a feeling here some years ago that it was necessary to change the seed every few years. On the experimental farm at Brandon, at the close of my eighteen-year term there, we had the same oats—Banner oats—that we had when we started, also the same Red Fife wheat, and barley, and each period of five years saw a noted increase in the yield; but we were exceedingly careful what land our seed grew on. If possible, we grew the seed on new land, and then we cleaned it, fanning it three or four times. We were not satisfied unless the oats weighed 42 pounds to the bushel.

Hon. WALTER M. LEA, Commissioner of Agriculture, Prince Edward Island: I have been very deeply interested in what I have listened to during the present conference, and particularly with the class of men that you have in the employ of the different Departments of Agriculture, because I know the difficulty at the present time of securing trained help. I like the calibre of these men and the evident impetus they give to the work that is being carried on. It is very valuable to this province. I may say your problems are altogether different to ours in Prince Edward Island. They seem to be climatic, particularly in regard to the amount of moisture. The problem of the farmer is made up of a good many different divisions, particularly that of a live stock farmer. The farmer who grows a crop of grain and harvests it all in the fall has many such difficulties as you have been discussing here to contend with; but the man who grows a crop in the summer season, and attempts to manufacture it into a higher class or live stock product of some nature, has often difficulties which require great intelligence to get the most out of his raw products—it requires a different class of skill. The class of animals he selects, the care and housing he gives them, and his knowledge as a feeder in blending feeds, are some of the problems the live stock farmer has to meet.

In connection with the problem of seed grain which Mr. Newman has been discussing, a farmer has to face many different conditions. The spring, when the farmer attempts to select seed, is a most important season. I was struck with the remark of Dr. Saunders, that he was amazed that a farmer who would pay a big price for an animal would be satisfied to sow indifferent grain. It is true, and it is a strange thing too, that a great many live stock men, who will make a very careful selection of their breeding animals, are almost indifferent about the class of seed they sow. It seems to have a great deal less importance than the class of stock. All of these things are of importance, and we must look

upon each of them in turn as being a particular problem. From the time the land is fit to work in the spring, the selection of seed and the cultivation that a farmer is able to give it, the saving and good housing of the crop, the turning of it into live stock products, and getting the fertility that has gone from the farm back on the land again with the least possible loss, are problems we have to face, and in these we are subject to great losses. I sometimes think that we as farmers—I myself have farmed practically all my life—are great wasters. There are a great many opportunities for waste. We are often farming with much too little help, and, for one reason or another, are continually meeting conditions in which we are noticing losses. If all of us could carry out the things we know should be done, we would be doing a great deal better farming, but it is a matter of doing first things first—of attending to the most important things. Your problems are of expansion and conservation of moisture and control of land drifting; ours are to make the most of the little area of country we have, to farm it more intensively, and to grow those things we specialize in, such as seed grains and seeds of various kinds, that will require, and to which we give, more labour.

When we look at the different phases of this question and see, as Mr. Newman has pointed out, what it would mean in the number of bushels of grain that might be produced, if the seed were of of a little better quality, to the total value of the crops of Canada, what it would mean if better farm practices could be obtained so that more moisture could be secured, and what it would mean in some of the eastern provinces if a better class of stock could be obtained all over Canada—all of these things would mean millions of dollars annually to this country, which needs so much more revenue at the present time.

Provincial Government Co-operation

F. H. Auld, Deputy Minister of Agriculture, Saskatchewan: The Commission of Conservation, our experimental farms and the colleges deserve a very great deal of gratitude from all of us. Posterity will probably admit the debt more than the present generation. Our experimentalists and the Commission of Conservation with them are doing a very valuable work in laying down policies which will be followed when they have to be followed. Medical science has done a great deal for humanity in its investigation work which enables them to deal with disease in the human family, but it is only when the disease exists that we go to them for assistance, and that seems to be the unfortunate characteristic in connection with our agricultural problems. We have been so busy trying to combat drought that we have got into the other difficulty of drifting soils; we have been so busy growing grain that we have got into the difficulty of growing weeds; and it seems to me the solution of these problems comes from the adoption of a proper system of rotation. But it has been the history of all pioneer districts, and Western Canada is no exception, that these changes only come when they are forced by an outraged nature whose laws we have violated, and we are compelled to take stock of our affairs and to reconstruct a better agriculture. The settlers in California admit that they were practically on the verge of bankruptcy, so far as their farming was concerned, before they changed into a system which has proven to be a better and more profitable system. I was reading a short time ago of conditions in Wisconsin, probably one of the best bearing states in America, where six years ago the farmers were considering seriously leaving their land because they were no longer able to grow wheat. Up to that time Wisconsin had been one of the leaders in wheat production in the United States. A lot of them were leaving for newer soils further west, newer districts, and they solved their problems and overcame their difficulties by getting a right kind of farming rotation. We have been interested for some time in the problems of southwestern and western Saskatchewan, which are similar to other areas in Western Canada in that they have not had a sufficient amount of precipitation in the past three or four years to make grain growing profitable. We find there the tendency of people to wait until they were in difficulties before they were ready to listen to suggestions and advice. Fortunately, we have the assistance and advice of a great number of agriculturists. At a conference that was attended by a large number of farmers from all over the area, these questions were discussed with breathless interest, because they realize their problem and the need for assistance in its solution. These people, during the past six years, were attempting to grow grain with a level of world prices which has never been equalled perhaps in the experience of any person here and which will probably not be repeated. During that period of six years, we find that they were going behind with their farms, due to the vagaries of an uncertain climate, not producing the quantities necessary to make a sufficient income by their farming operations to be a success. It was suggested that there should be a greater utilization of precipitation, that there should be greater diversification of crops and that some steps should be taken whereby their entire crop would be used, and not merely the grain portion of it only, which has been the case up to the present; in other words, that there should be more live stock on every farm other than horses. By raising live stock the roughage which is produced along with grain should be conserved and turned into meat, which is also a cash product. Every asset which they have in that area should be utilized, and not merely a portion of it, as at the present time. Just as soon as the people realize the need for adopting a different system and no sooner will they be guided and advised by the experts who are at the service of the Canadian people.

H. A. Craig, Deputy Minister of Agriculture, Alberta: I want to express my appreciation of the fact that the Commission of Conservation have taken this work up. They have given evidence of the fact that they are alive to the situation in Western Canada. They realize that we have some problems confronting us, and I want to say that I most heartily agree with them in their decision in calling such a conference as this. It seems a pity that many of our farmers throughout Western Canada could not be here to take advantage of the addresses. Some of them, perhaps, would not be of such a technical nature if the farmers were present. These men have spent many years in obtaining the results which they have given to us in such concise form. I listened to the speeches on fertility conservation, the conservation of soil moisture, the introduction of fibre into the soil, crop rotations and a good many other things that have been ably discussed, and I am quite in agreement with everything that has been said. It applies to the major portion of our province, and I believe that the farmers concerned will adopt those methods just as fast as it is possible for them to do so. The men owning the greater portion of the land in our province are progressive; a lot of them are able to do the things they should do, but I am concerned about the few men who are up against it in Alberta to-day. There are men who are struggling with the problem of making a living. That, I am pleased to say, is confined to an exceedingly small area. But what are we going to do to help these men? I believe that what has been said respecting soil moisture is true, that the question of rainfall,—of conservation of moisture—is by all means the most important question to that territory to-day. The Medicine Hat district, where smaller crops have been grown during the past three years than in most parts of the province, has the most productive soil in the whole province, provided you can get moisture. I have seen some of the finest crops in Alberta growing in Medicine Hat, when they had sufficient moisture. We have sufficient fertility to last a great many years. I am not saying that we should not conserve that fertility, but the question of those men to-day is to make a living.

The irrigated land in southern Alberta will, in ten years, I believe, be amongst the most profitable and productive territory in the province. I am satisfied, when we get an intensive system of agriculture into operation in that district, that we will have the most prosperous people in our whole territory. I believe that the secret of success in this work depends on how many live stock we can get into this territory. I believe that the district which to-day is suffering in Southern Alberta on account of lack of moisture, when present projects get under way, will also be an exceedingly progressive territory. The introduction of fall rye will help these men very materially in the production of a crop. That, as some of our men have advised us, will keep this moisture for a long period, it will grow under fairly dry land conditions, it will produce a paying crop. But we must improve the kind of rye that is sown. I have seen a sample of rye that had kernels nearly half an inch long, an exceedingly heavy sample; most of the rye that you find over the country is not a quarter of an inch long, and the difference in yield would be just about double under similar conditions.

The growing of sweet clover will materially help the situation. I have seen in southern Alberta crops of sweet clover on which cattle and hogs were pasturing and doing well. It has a heavy carrying capacity under dry land conditions, and even under proper conditions we find sweet clover is doing well. The time is soon coming when we will have more silos in southern Alberta. The silo again is a partial solution of our problem. Men who will put sweet clover, alfalfa, corn, peas, or oats, or whatever they may grow, into the silo, will find it a paying proposition.

J. H. Evans, Deputy Minister of Agriculture for Manitoba: It is one thing to work out a programme for Western Canada; it is quite another matter to get

the farmers to accept that programme. They may agree with the advice given, and desire to put it into effect, but factors which appear to be beyond human control seem to militate against putting this advice into effect. There is, however, quite a change in the public attitude. I remember when I first entered an Agricultural College, the statement being made—"Well, there is another boy leaving the land." When men left our own institution in Manitoba to go back to the land, they were greeted more or less questionably. Gradually, there is a change, and the men are filling their places in their district. I remember the advice given by the head of the institution, that the agricultural college was training men for leadership. We find that the men who have gone out of our institutions and are farming in our districts are finding their place and are gradually—and it is a good thing that the change is gradual—assuming leadership, and I think, speaking generally, the farmers realize that a change has to be made. We have been fortunate in Manitoba with respect to drouth. We had one small territory in the southwestern portion of the province which has suffered a partial crop failure, but even in these areas there were some good fields, showing that there is a way of overcoming the natural factors if we can find it.

Soil Moisture

BY

PROF. E. S. HOPKINS

School of Agriculture, Olds, Alberta

THE subject of soil moisture lends itself to discussion under three subdivisions, first, precipitation records; second, evaporation from the surface of the soil; and, third, the amounts of transpiration from various crops. All these factors affect soil moisture.

One of the most important factors, if not the most important, in crop production in Western Canada is the amount of precipitation. Sufficient moisture in the soil usually ensures a profitable crop. However, other factors may limit production; the soil and seed may be blown away; cutworms and grasshoppers may eat off the crop; weeds may choke out the grain; a hot wind may burn it up; excessive rain may bring rust and blight the crop; it may get frozen or hailed, etc. I feel convinced, however, that in Western Canada, precipitation is the most important single factor. If a dry year comes or, worse, if two or more dry years come in succession, the farmer is placed in the most serious financial straits.

It seems to be the duty of the Government to undertake experimental work which has for its object the correction of these conditions because the experience of the farmers has been a most dismal failure. For three years now in many parts of the west the farmers have been dried out and almost ruined; experience alone has not accomplished anything.

Precipitation Records

A study of the precipitation records throughout Western Canada is very important. It is impossible to judge the value of a district by the rainfall of any one year or even of three or four years; it is necessary to examine the records for a longer period. Short records, or the mere opinion regarding rainfall of residents in a district, are liable to be very misleading. Fortunately there are, for several districts, accurate data regarding precipitation which have been collected by the Dominion Meteorological Service.

The statistics used are for northern and southern Alberta—for Edmonton and Lacombe in the north and for Medicine Hat and Lethbridge in the south. The figures at Edmonton and Medicine Hat have been recorded for over thirty-six years, while those at Lacombe and Lethbridge have been recorded for approximately seventeen years. These periods are of sufficient duration to enable fairly reliable deductions to be drawn, and the recording stations may be safely said to be representative of some of the moister and some of the drier parts of Western Canada. For these reasons, therefore, it seems advisable to examine in a fairly critical manner the precipitation records in these places. The examination reveals several rather interesting and important points. (See figs. 1 and 2.)

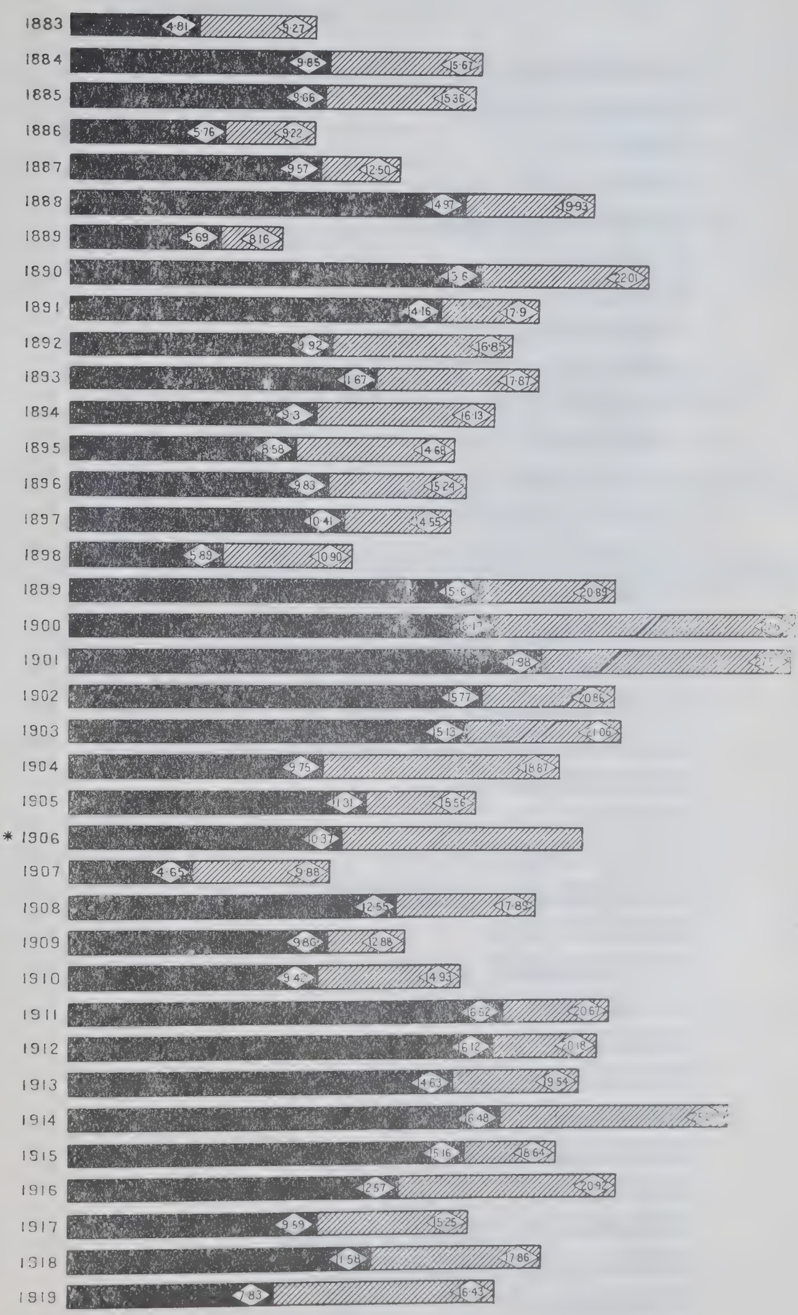
The average annual precipitation at Edmonton is 17.21 inches, while at Medicine Hat it is 12.77 inches. It is not the average total annual precipitation, however, which is of most value in making deductions. It is the minus departures from this normal which give us the greatest concern. If we were sure of the average precipitation, in many parts of the west, our crops would be more successful. These figures show that there are many serious dry years in the Medicine Hat district. These diagrams seem to confirm the view that dry and wet years go in cycles, but other charts made for other districts contradict this impression.

PRECIPITATION AT EDMONTON

37 YEARS RECORD

Season: April, May, June, July, August..........

Total for Year (Figures indicate precipitation in inches).



* Precipitation data for March not available; estimated by comparison with Calgary.

Figure 1

PRECIPITATION AT MEDICINE HAT

36 YEARS RECORD

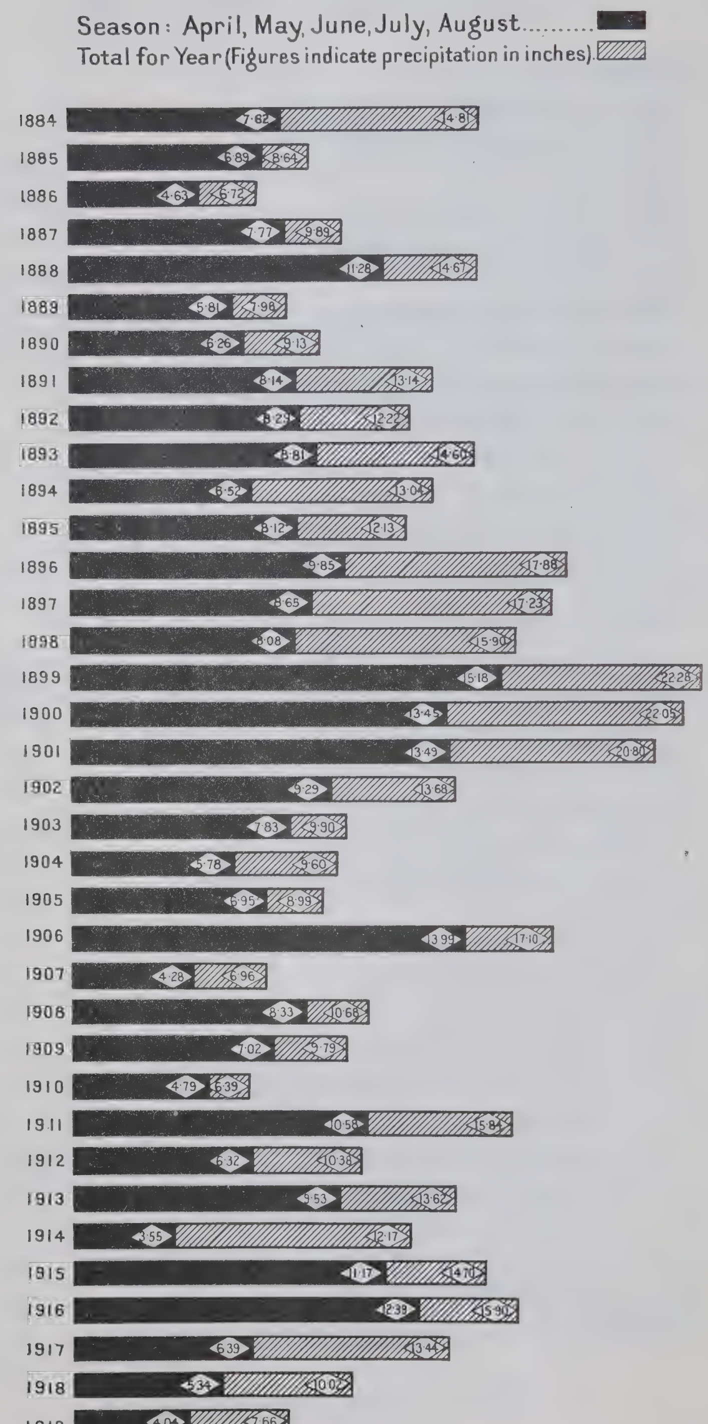


Figure 2

Rainfall During the Growing Season

It is not so much the total yearly precipitation which is important, as it is the rainfall during the growing season. The winter snowfall may melt and run off into sloughs, while the spring and fall rains may evaporate before the spring-seeded cereal crops can utilize the water. It is the rain which falls in the growing season which is the most important.

Turning again to Edmonton and Medicine Hat (figs. 1 and 2) let us examine the amounts of rainfall during the growing season, and here let me mention that the growing season at Edmonton for oats and wheat is almost a month longer than at Medicine Hat. Taking statistics from the reports of the Dominion Experimental Farms at Lacombe and Lethbridge, which may be said to represent with fair approximation the crop development at Edmonton and Medicine Hat, it will be found that, while during the years 1908 to 1915 Lethbridge harvested oats on an average on August 6, Lacombe harvested oats during the same period on September 1; moreover, at Lethbridge the oats were seeded only four days earlier than at Lacombe.

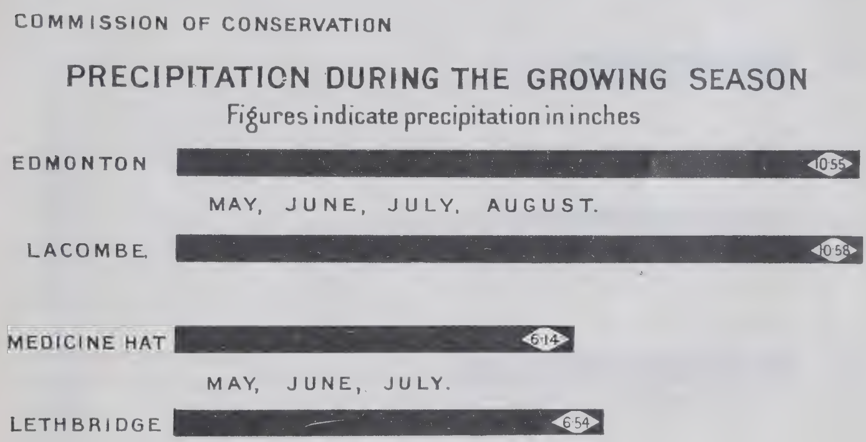


Figure 3

The precipitation at Edmonton and Lacombe during the growing season of May, June, July and August, and for May, June, and July at Medicine Hat and Lethbridge is shown on fig. 3. One could, of course, include April, because, ordinarily, the grain is seeded in April; on the other hand, the rainfall is not very heavy in April and, as the crop is not high enough to shade the ground, the evaporation from the soil is considerable. This chart shows how much less is the rainfall in Medicine Hat than in Edmonton during the growing season.

It may be of interest to show what the rainfall actually is during these months.

	May	June	July	August	Total for 4 mos.
(36 years)					
Edmonton	1·66	3·11	3·42	2·36	10·55
Medicine Hat	1·69	2·65	1·80	1·47	7·61
(17 years)					
Lacombe	2·22	3·58	2·61	2·13	10·54
Lethbridge	2·37	2·62	1·55	2·01	8·55

It will be seen that the months of May and June at Edmonton and Medicine Hat are not far apart, but that the month of July is considerably lower at Medicine Hat than at Edmonton. This is a most serious factor, because July is the month which needs rain the most and particularly in the south where, in this month, the crop matures so rapidly.

The figures for Lacombe and Lethbridge, which are for a period of much shorter duration, confirm the figures for Edmonton and Medicine Hat.

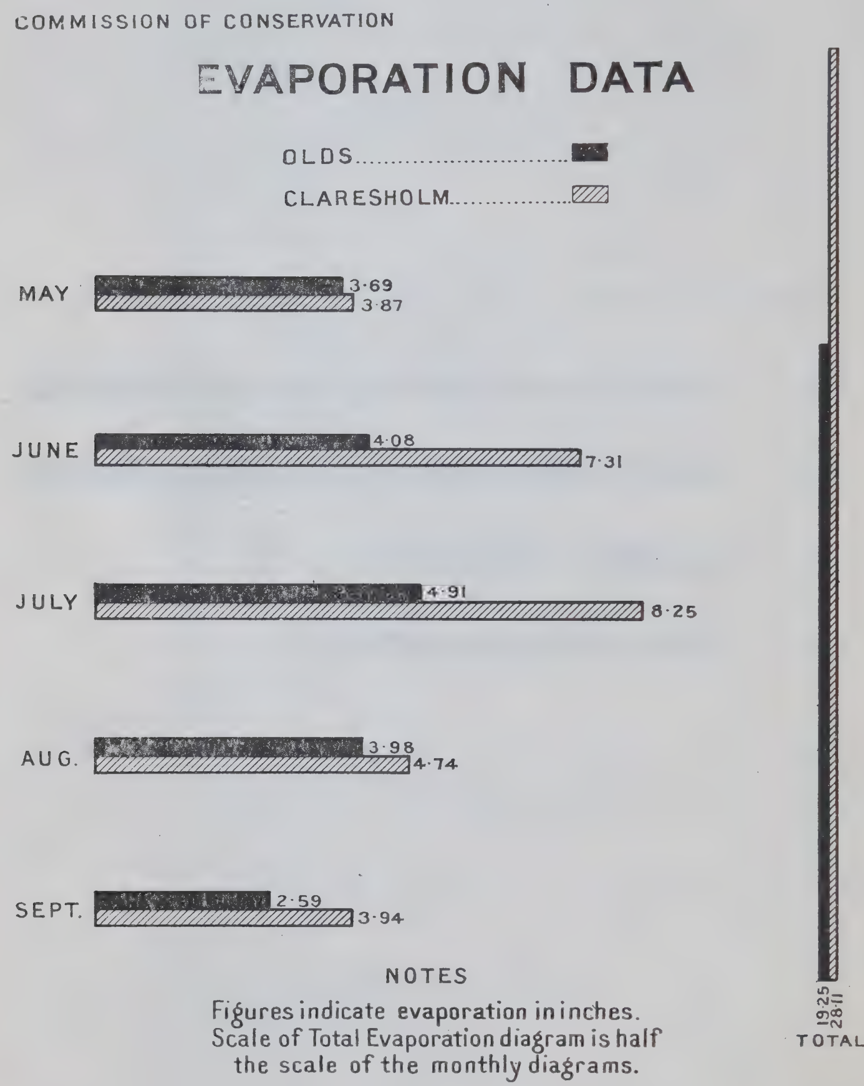


Figure 4

Evaporation of Moisture

It is not the total rainfall during these months, however, which is the most important point. The south has much more evaporation than the north, and the greater the evaporation the less effective is the rainfall. Last year, at Claresholm and Olds, we installed evaporation tanks four feet in diameter and two feet deep, which were filled with water; these were sunk in the ground so that the surface of the water was on a level with

the ground, and we recorded the amount of evaporation. During the growing season the evaporation at Olds was nineteen inches, while at Claresholm it was twenty-eight inches; the differences in rates of evaporation were greatest during the months of June and July. (See fig. 4).

Temperature is Important

The temperature also has an important bearing. Taking as an average the last four years, the maximum temperatures at Edmonton and Medicine Hat during the months of June, July, and August, it will be found that in the various months the following number of days had heat temperatures as designated:—.

	80–90	90–100	100–
June—			
Medicine Hat	8	5	1
Edmonton	3	0	0
July—			
Medicine Hat	13	12	1
Edmonton	8	0	0
August—			
Medicine Hat	16	5	0
Edmonton	3	0	0

These temperatures show how much warmer it is in the south than in the north, and indicate, perhaps, the possibility of a greater adaptation for certain crops.

Another angle from which these precipitation figures may be viewed is to examine a frequency table showing the number of years in which the rainfall during June, July, and August falls between certain limits. The following frequency Table of Precipitation shows this:—

Inches	Edmonton—No. of years in			Medicine Hat—No. of years in		
	June	July	August	June	July	August
0·0—0·5	1	1	2	3	2	9
0·5—1·0	3	1	5	2	9	6
1·0—1·5	1	1	4	2	5	5
1·5—2·0	4	2	5	6	9	5
2·0—2·5	2	8	4	6	2	7
2·5—3·0	7	3	5	2	5	0
3·0—3·5	4	6	2	4	0	2
3·5—4·0	6	4	1	4	2	0
4·0—4·5	5	4	5	3	0	0
4·5—5·0	1	1	1	1	2	1
5·0—6·0	2	3	0	2	0	1
6·0—7·0	0	1	1	1	0	0
7·0	1	1	0	0	0	0
Total years	37	36	35	36	36	36

It will be observed that at Medicine Hat in the month of July there were, during the last 36 years, 16 years in which the rainfall was less than 1.5 inches and 25 years in which it was less than 2 inches.

Water Requirements of Crops.

Now, if it were known how much rain were needed to produce various crops, and when and in what amounts it should be given in the various months, it would be possible to determine how many years out of the past thirty-six had produced crops successfully. We have done some of this work at Olds, and I wish to review briefly the results. We found that for transpiration alone it took five inches of rain to produce fifty bushels of oats; evaporation from the soil would increase this amount. In the south these factors would be larger.

More experimental work is needed to discover these points; experiments on the water requirements of crops should be done in southern Alberta. These experiments are indispensable aids to any study on methods to avoid the effects of drought in dry areas.

Moisture in Growing Season

There is also another point. Perhaps the combined rainfall of May, June, and July may be adequate to produce crops when one month alone might be insufficient. Adding the rainfall for the months of May, June, and July at Medicine Hat it is found that out of thirty-seven years there are thirteen years in which the combined rainfall is under five inches and six years when it is between five and six inches. (See table, p. 55.)

These records indicate that the practice of growing spring-seeded cereals, like wheat, oats and barley, is extremely risky. There are too many years in which the rainfall is too low to produce profitable crops. It indicates, in the strongest possible manner, the absolute necessity of changing this system, and of growing a much larger acreage of other crops which utilize the moisture throughout a longer period of the year; such crops as fall rye, corn and sunflower.

The object of using a comparison between Edmonton and Medicine Hat is not to show one district in a more favourable light than another, but it is absolutely necessary to place the figures from a dry district alongside the figures from a more humid district in order that a more intelligent study may be made. Moreover, at Edmonton and Medicine Hat meteorological data for a long period of years are available.

Change System of Farming

There is no denying the fact that portions of the south country have been dried out for several years and that the farmers are in a serious condition. The Governments, both Provincial and Dominion, have spent millions for seed grain, feed for stock, shipment of stock to areas where more grass is available, and relief for the farmers and their families. It is clear, either that portions of the dry district are not suitable for farming and should revert to grazing lands or, as seems more probable, the present system of farming is not adapted to this country. These points should be definitely studied and experimented with in order that further financial losses may be avoided.

Evaporation from the Soil

It is an interesting fact that at Cornell University, New York, where the average annual precipitation is about 32 inches, percolation through the cropped soil is about 50 per cent, leaving as evaporation from the soil and as transpiration from crops 16 inches, which is approximately the amount of the annual precipitation throughout many parts of Western Canada. This is a very important point; it seems to indicate that, with soil of this type, about 16 inches of rain would be, perhaps, nearly the optimum amount, because the rainfall in excess of 16 inches percolated through the soil and leached away valuable plant food.

There are not available for Western Canada or, as far as I am aware, for the Western States, any records of such percolation work as has been done at Cornell University by Dr. Lyon. Such work, however, is most urgently needed.

Experiments conducted at Olds, Alberta, showed that fall rye utilized the precipitation which fell during the fall, winter and spring in a very effective manner. Last winter, from October to May, there was at Olds approximately eight inches of precipitation. The soil had saved in the spring what was equivalent to four inches of rain, a very considerable amount.

Effective Utilization of Moisture

It is of vital consideration to learn how this moisture can be most effectively utilized. Fall rye, by providing a covering over the surface of the soil and by making a much earlier growth, utilizes this moisture much more effectively than spring-seeded cereals. In the month following the date of seeding of spring cereals, in which period 1·5 inches of rain fell, it was found that the soil on which fall rye was growing had made a considerable growth, but had not lost much more moisture than the soil growing spring-seeded cereals. Fall rye which has a fair amount of top growth conserves the moisture more effectively than when there is a shorter growth. This work was conducted in cans 30 inches deep and filled with layers of soil in the order in which they occurred in the field. The cans were weighed regularly, which permitted the collection of accurate data.

Fall Rye Absorbs Most Moisture

Another significant fact brought out was that, due to the extensive root system of fall rye, it makes a much more satisfactory utilization of soil moisture than do the spring-seeded cereals with their shorter root development. Fall rye, which, in the cans, had its root development reduced to 30 inches, is now only three feet in height, while rye growing in the field on similar soil, but with, of course, unlimited opportunity for root development is six feet high. Moreover, the rye seems able to absorb a much greater percentage of the moisture content of the soil than does spring-seeded cereals.

Experimental work with evaporation at Olds shows that light showers of rain are of very little value unless the soil is already moist on top. One-tenth of an inch of rain, falling on a dry soil free from vegetation, is lost on a warm summer day in less than twelve hours; almost an inch of rain is lost from a dry soil in one week. When the crop covers the soil the evaporation is very much checked.

Water Requirements of Crops

Inseparably connected with precipitation and evaporation from the soil is the quantity of water which crops require to produce their growth. Considerable work of this kind has already been done, but in other countries than Canada, namely, in the United States, England and Germany, where conditions of soil and climate are not similar to those which obtain here.

Experiments With Crops for Drought Resistance

In a country where the rainfall is the limiting factor, the discovery of crops which are economical in their use of soil moisture is invaluable. It is only possible here to give a brief outline of the method used to secure this data and to present some of the results. Various crops have been grown, in cans 30 inches deep and 15 inches in diameter. The soil has been taken from the field in layers, each layer of soil has been thoroughly mixed to insure every can receiving uniform soil, and the layers of soil replaced in the cans in the order in which they occurred in the field. The cans are covered with lids, which have openings to allow the grain to grow, these openings being sealed to prevent access of rain or escape of evaporation. The cans, which, when filled, weigh about 240 pounds, are weighed regularly and additions of water are made through openings in the tops of the cans.

The work having been started only last year, we were able to secure figures only for spring-seeded cereals and for a small crop of sweet clover and alfalfa. The results were surprisingly lower than had been found in other districts. It made us hopeful of discovering methods which might be more successful here than in the Western States where the temperature is warmer.

The following figures show the number of pounds of water required to produce one pound of the various crops, at Madison, Wisconsin; Akron, Colorado; and Olds, Alberta.

Crop	Madison, Wisconsin	Akron, Colorado	Olds, Alberta
	lb.	lb.	lb.
Wheat	....	507	271
Oats	541	614	306
Barley	388	539	227
Peas	477	800	240
Corn	350	369	179
Alfalfa	....	1,069	478
Sweet clover	....	709	451

Favourable Conditions in Alberta

The one outstanding fact in connection with these figures is that in Alberta the water requirements of crops are very much lower. There are several reasons for this; the temperature is cooler, the evaporation is less, and the number of hours of sunshine is very much greater, which increases the photosynthetic action and promotes more rapid growth. These factors are very important, but they need more study and more experimental work if the fullest use is to be made of these advantages.

The question of drought resistance is not simply the selection of those crops which require the smallest amount of water to produce a pound of dry matter. Other factors are also of considerable importance. Some crops are able to remain in a dormant condition during periods of extreme drought and to resume their growth when more moisture is available. Other crops, under similar conditions, succumb. It remains, then, for us to discover those which are able to enter into these periods of dormancy, if we are to overcome the dry periods which, unfortunately, sometimes occur in this country. Sunflower is a crop which is able in this manner to withstand drought, as is also brome grass. Additional crops possessing this characteristic should also be found.

Some crops take out of the soil more moisture than others. Last year, at Olds, we found that while timothy reduced the soil moisture to about fifteen per cent, brome grass reduced it to about nine per cent. Moreover, timothy produced only about one-half ton to the acre while brome grass produced three tons. Fall rye seems able to reduce the water content of the soil to a lower percentage than do the spring-seeded cereal crops. This point should be more thoroughly investigated.

Must Discover Suitable Cropping System

It seems possible for us to discover some system of cropping in which, say, after summer-fallow, a crop is seeded which requires a minimum of moisture, to be followed by a crop which, through ability to stand periods of drought and by possessing a more powerful root system, is able to extract the greatest amount of water from the soil. Such a system would be very profitable; every effort should be made to discover it.

I have pointed out some facts regarding our rainfall in the drier regions, some conditions in connection with the escape of moisture from the soil and some points in regard to the quantities of water required by various crops. These quantities of water are much less than those found in the United States which indicates that, perhaps, our farming methods ought also to be different from those practised there.

But, most important of all—in fact, if I do nothing more than this I shall be amply satisfied—I wish to emphasize, with the most sincere conviction, the

urgent necessity for more experimental work. If we are to save the farmers in some districts from ruin, and if we are to build up a prosperous and stable Western Canada, we must learn how to avoid the calamitous losses which occur in our dry years. The experience of farmers cannot do this; publicity and extension cannot do it; experimental work alone can accomplish it. We must study by scientific methods how to make farming more profitable and more permanent.

Dr. GRISDALE: I would like to ask Professor Hopkins if he thinks the comparison of the precipitation of the north and the south quite fair, so far as it affects crop production? Would it not have been fairer to have included August in the southern precipitation as well as in the north? It could be conserved in some considerable measure in the summer-fallow, at least. Would it not have been fairer to have included the bald precipitation as well in both districts, separating them, I think, possibly advisedly, and just have considered them? The amount of moisture conserved in his can from the precipitation in, I think he said, September, October and the winter, was about 50 per cent, which makes a pretty good start. If 50 per cent of eight inches is conserved, four inches remaining at the first of May and there is no precipitation in May, the crop is quite safe on summer-fallow at least, and that would overcome that year or two when May had no moisture. This also affects the crop-producing power of land during other years. I would like to hear his views on those points.

Professor HOPKINS: If I included the precipitation of August for the drier region it would more closely approximate in amount that of the moister region and in the earlier tables I included August for both regions. However, in the south, the crop is harvested about the 1st of August and hence precipitation in that month does not benefit it. With respect to the utilization of the winter precipitation I do not know how much weight should be placed on it. Of eight inches which fell from October to May, four inches were conserved in May. At that time, however, spring had not passed and of that four inches which was conserved there was really less than one inch a month later on the land which did not have any crop. A wide difference of opinion exists as to the amount of moisture that can be brought through on a summer-fallow. On some experimental work done in the United States, which, unfortunately, cannot be used here because of the higher temperature there, the amount which came through to the first of May was a very small fraction.

Dr. GRISDALE: The chance of summer-fallow moisture coming through to the first of May is much greater in Canada than it is in the southern states. Did the soil in the can—from which you arrived at the conclusion that it was all gone, to one inch, at the end of June—receive any surface cultivation?

Professor HOPKINS: No.

Dr. GRISDALE: That would not make it comparable to field conditions.

Professor HOPKINS: On some other cans on which we did work we did not get very much difference. I did not mention them.

Dr. GRISDALE: There is no denying that mulch conserves moisture.

Professor HOPKINS: It may. We have read of that for many years, but the amount which it will conserve is so small, I would not like to bank very much on its effect upon the crop. It may be good in ways other than the conserving of moisture. I believe, in regard to the loss of moisture from the surface of the ground, it is not now known how it gets out. I did not hear what Mr. Cole said at Swift Current but I have read the bulletins published by Chilcott, Cole, and Burr on this topic; they came to the conclusion that there is a possibility of the water going into vapour and passing off in that way rather than through the action of capillarity.

Mr. Fairfield: On that point, Prof. John S. Cole, of the Dry Land Investigations Branch, United States Department of Agriculture, has stated that from their experiments, extending over all parts of the western part of the United States, from Arizona to Dakota, they had come to the definite conclusion that it was very doubtful whether the soil mulch really affected the loss of moisture by evaporation from the soil. He said it was a very startling statement to make, but he said that was about the conclusion they came to as a result of their experiments. The principal reason it is interesting is that it is so very unorthodox. I wanted to ask Mr. Hopkins in regard to his can experiment, what amount of moisture was in the soil before the eight inches was added. The reason I ask is that if the moisture was fairly high and the eight inches of moisture was added, the evaporation would certainly be very much greater than if the soil was practically exhausted of moisture before adding the eight inches.

Professor Hopkins: The cans were filled about the last of September and the moisture content was just as it occurred in the fields. If I gave a definite percentage it might be misleading. It would depend on the organic matter. Some analyses made it around 30 per cent. Speaking in general terms it was in just fair condition in respect to moisture content.

Dr. Grisdale: I am glad that this fact, in connection with the conservation of moisture, has been brought out at this meeting, because it has long been a debatable question. I would not like to have the idea go out, as having been accepted by this meeting, that there is no advantage in attempting to make a mulch of the ground. It may be that the mulch does not conserve soil moisture to the extent often attributed to it, and which has very commonly been accepted in the past as the case. However, that may be, we do not want to leave the impression that we do not put any value on soil cultivation after ploughing or any preparation of the crop for the next year. While the mulch in a field that is in perfect condition otherwise may not conserve soil moisture, it must be admitted that if you plough a field and then fail to pack it or cultivate it or firm it down you are going to lose very much more moisture, for the reason that the air comes in contact very much more freely with the soil, and for a considerable depth there is a freer circulation of the air than where the soil is firmed down. Therefore, I am of the opinion that, if we let it go out from this meeting that it is not necessary to do any cultural work after ploughing, we would be leaving a very wrong impression indeed and I would like to have Prof. Hopkins deal with that point.

Professor Hopkins: Until we get definite data, of course, it is best not to make too startling statements. I may be wrong. The question of cultivation of the soil has many other effects than that of conserving moisture. It undoubtedly has the effect of aerating the soil, promoting oxidation and therefore making soluble plant food which would otherwise be insoluble; it also promotes bacterial action which is related to productivity. So far as crop methods are concerned, I would not say the lack of cultivation would be quite as good as the presence of it. Just how much of that cultivation should be given with profit is a point, I think, we will have to look into.

The Chairman: From anything that Professor Hopkins said I do not gather any suggestion that summer cultivation and a mulch were not good for the subsequent crop. The facts are that it has been a good thing. The question was whether the explanation would fit the facts. Many a good man has his opinions turned down because his explanation as to why he holds them is faulty, while the opinions themselves may be based on real observation in life. I take it that Professor Hopkins has not challenged at all, nor cast any doubt upon the validity of the practice of summer cultivation and a mulch to get crops; the question is whether that practice is conducive to the capillary move-

ment of water, and holding that water down. I have had a lot of explanations shattered in recent years, but it has not shattered my conviction when I have seen a good crop off mulch.

I wonder if Professor Hopkins is ready to make any further suggestion of a low water consuming crop for a district, because, after all, the object is not to use the water in a way that seems complete and advantageous to the water but to get a good crop. The question is, has he any suggestion of a crop that would suit the conditions out there and that could be sold out there under existing conditions. He did suggest corn; is there any immediate probability of marketing the sunflower which he mentions?

Professor HOPKINS: In addition, perhaps, to corn and sunflower, fall rye offers some possibility. We need, however, a great deal of work before we can come out and say much very definitely. The question of soil moisture is absolutely related to the profit end of farming. The fact that spring-seeded cereals do not apparently grow at the best time to economically use that water leads me to think that perhaps a greater acreage of some of the other more drought resistant crops should be grown, in the hope that in dry years the farmer may overcome his difficulties.

Professor HANSEN: Has Professor Hopkins any information as to the comparative amount of water required by a spring wheat crop as against a fall wheat crop in the same locality?

Professor HOPKINS: We have that under investigation at Olds now, but the data will not be available until this fall. Last year we started this work but could only get the data from spring-sown cereals. We will have the data for both spring and fall wheat this autumn.

Mr. PEARCE: Some few years ago, there was quite a large development in winter wheat in southern Alberta; it gave promise of supplanting spring wheat altogether, and it particularly showed its ability to overcome the lack of moisture. The winter wheat was attacked at the lower roots by a parasite, after we had it for a few years; the result was we went out of winter wheat almost altogether. Has that question, as to this pest, ever been settled, so that we can safely go back to winter wheat?

Mr. FAIRFIELD: It is rather hard to explain the reason why winter wheat has ceased to give the results that it did in the past. My personal opinion, from observation, is that in the early years practically all winter wheat was sown on May and June breaking and the cultural conditions were ideal for the wheat; plants therefore went into the winter in a stronger and more vigorous condition and better able to winter through. In 1910 and 1911, however, the trouble that Mr. Pearce speaks of was apparent in a great many fields, indicating a weakened condition. The Entomological Branch of the Department of Agriculture sent out Mr. E. H. Strickland to study the situation, the idea being that it was an eel-worm. Mr. Strickland concluded that, while he found some eel-worms present, it was very doubtful if they were causing the trouble, that it was more likely some fungus disease and that the eel-worm followed. On account of the diseased condition of the plant at that time resulting from the fungus the area devoted to winter wheat was considerably reduced. The war coming on, investigation was discontinued and has not yet been resumed. Personally, I think that the condition of the soil had more to do with it than anything else, because we have raised winter wheat on the experimental farm every year, and we have a great deal more winter wheat now, all planted on summer-fallow under apparently similar climatic conditions, than we ever had when we first put it in on freshly broken soil. I do not think that as yet there is any real lacking of the constituents in the soil; it is more its physical texture. Winter rye is rarely killed out. Perhaps it could be illustrated this way, winter rye is hardy, and winter wheat is top hardy.

The CHAIRMAN: Recently there have been many careful investigations made as to why some trees are killed some winters and others winter-killed at a certain temperature; also some research as to the moisture contents of the roots and as to whether a more constant and more gradual reduction of temperature does not affect them; and also whether more or less protection does not enable them to escape. It is for us in Canada by investigation to find that out in regard to winter wheat; by so doing we may be able to overcome the difficulty. That is why I advocate research, research, and again research, by competent brains and hands and eyes. I think no one can more than surmise as to why winter wheat gets killed and why it gets killed some years rather than others. Last year in Ottawa, more plants were killed than in some years with more exposure. Perennials were killed that have stood the test for ten years. What is the nature of the disease—call it a fungus or anything—and how can we deal with it? If we get to know the why, we will be able to get to know the how

Maintenance of Soil Fibre

BY

PROF. T. J. HARRISON

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AMONG the factors which tend to reduce the profits in crop production there is none more important than drifting soil. In an average of five years the loss due to this source is probably as great as that due to rust. Up to this time practically no work has been undertaken in the Canadian west toward the solving of this problem. I will therefore confine my remarks to the results of a preliminary survey of some of the soil drifting areas of Manitoba made by the Field Husbandry Department of the Manitoba Agricultural College.

Method of Conducting Investigation

The survey consists of locating a number of areas where drifting was reported to be bad, and sending out a man to ascertain in a definite area the amount of drifting taking place in the various fields; to learn from the farmers the method of farming followed on each field, and to collect soil samples from the various fields; these will later be analysed by the soil chemist and soil physicist.

Experimental fields will be located on some of the worst drifting soils in the various areas. On these fields different methods of soil and crop management will be tried out. These fields will be operated on the plan of the Conservation Commission Illustration Farms, excepting that, instead of being operated as demonstrations, they will be operated as experiments.

Areas Surveyed

The areas surveyed were those from which drifting was reported and which were easily accessible from the college. They are probably not the worst affected districts in the province and are certainly not as bad as those discussed by the representatives from the more western provinces. The conditions, however, in the districts surveyed to date, Portage Plains, Carberry Plains, Glenboro Plains, Carmen Plains, Souris and Wawanesa, were alarming.

Type of Soil Most Liable to Drift

The first thing to establish was the type of soil most subject to drifting. In the areas surveyed we found sandy soils, sandy loams, loams and clay loams. One of the samples was taken near the town of Rossendale, and may be classed as a sandy soil. The land from which this sample was taken was being farmed by a man who used no summer-fallow at all, because he dare not leave his soil without a cover crop or it would blow away. Even with this precaution it was drifting badly. Other samples are of the sandy loam type, and were secured from the Carberry plains, Glenboro plains and around Souris. In these districts, some farmers, by control methods which will be discussed later, were holding the soil, but much of it was drifting badly. The loam samples were taken in the vicinity of Wawanesa, Carman and Portage la Prairie. The soil drifted to some extent but not as badly as the first two. In 1918 even the clay loam soil, 10 miles south of Winnipeg, drifted until it filled the ditches along the road.

The conclusion arrived at, therefore, was that any type of soil would drift; first, if it had been under continuous grain cropping for a number of years;

secondly, if the season was such that it caused the soil to disintegrate, and thirdly, if there were high winds during the months of May and June. The sandy and sandy loam soils were more readily affected by these conditions than the loams and clay loams.

Condition of Soil Responsible for Drifting

Since the clay loams and the loam soils did not drift badly, and the sandy soils are not cultivated to any extent, most of the time was spent in the sandy loam districts. By studying the history of the cropping and cultivation practices on the various fields, we endeavoured to establish, first, how long it was after the land was broken before drifting started, and secondly, the methods of cropping and cultivation that most readily produced drifting. The period which elapsed after breaking, before the soil drifted, varied from 5 to 15 years. The average was about 10 years. All of the farmers visited were emphatic in stating that *the drifting did not start until the virgin fibre had disappeared.* The fibre disappeared from the sandy loams much more quickly than it did from the clay loams.

The total of organic matter, as indicated by the ignition test (which, while not accurate, gives a good indication of total vegetable matter), has little relation to the tendency to drift. Two samples were compared, one from Souris and the other from Wawanesa. Both had been under cultivation for 30 years, both gave about the same evidence of drifting, the fence posts in both fields being completely covered with soil. The Wawanesa soil lost 12·1 per cent of organic matter, while the Souris soil lost only 5 per cent. Another sample taken from the sand-bank along the fence of the latter field lost 2·4 per cent.

The continuous cropping and summer-fallowing system mentioned by Dr. Grisdale as the typical Manitoba rotation—first year, fallow; second year, wheat; third year, wheat; fourth year, oats and barley—was responsible for the starting of drifting earlier than any other cause. For example, a sample was taken from the fields in the Carberry plains, which had been cropped for 20 years by the method outlined; another sample was from the virgin soil immediately adjoining. The cultivated field had been drifting badly for about 12 years. On an ignition test the cultivated soil lost 9·9 per cent, while the virgin soil lost 12·3 per cent. The continuous cropping had reduced the organic matter 2·4 per cent. This, however, does not indicate the difference in fibre content, for the virgin soil was full of roots, while the other, to the naked eye, was devoid of fibre. On the adjoining farm a cropping system, which included timothy every four years, was in use. This farm had been under cultivation for approximately the same length of time. Under ignition test it lost 11·7 per cent; showing it to contain 1·8 per cent more organic matter and bore much more evidence of fibre. This soil did not drift. Many other samples and observations bear out the same results.

The conclusion, therefore, was that the absence of fibre in the soil was the cause of drifting. Secondly, that, with present cropping systems, the virgin sod fibre was depleted in about 10 years.

Conservation Methods Determined by Local Conditions

It has been shown that all soil types drift and that wind, rain, etc., influence the amount of drifting. It is also conceded that the different types require different treatment. For example, a method that would conserve the fibre in the loam soils at Wawanesa might not be successful on the sandy loams at Souris. The problem, therefore, becomes a local one. Before it can be effectively solved in every district, a soil and climatic survey of the province should be made. From the data secured in the preliminary survey, however, a few general principles may be laid down. These, with modifications, may be applied to any type of soil.

On 75 per cent of the farms visited the farmers were endeavouring to prevent soil drifting by various methods of cultivation. The most general practice was an endeavour to eliminate harrowing and substituting packing, the theory being that the harrows broke the soil fibre and pulverized the soil, and thus induced drifting. The packer was partially successful in meeting the problem, but sooner or later the fibre disappeared and drifting started. Another scheme was to cultivate with a narrow-tooth cultivator when the soil was wet, before seeding. This "wet cultivation" was effective in preventing drifting. The difficulty with this scheme, however, was that it is usually in dry years that the drifting is worst. Other schemes were used by other farmers, but this type of work, when viewed on numerous farms, must be recognized as a temporary relief measure only.

Farmyard Manure

On limited acreage farmyard manure has proven successful, in both maintaining the fibre and preventing drifting. Two samples were secured from adjoining fields in the Wawanesa district. Both farmers followed the grain-summer-fallowing system of cropping. One applied manure on the field every two or three years. The unmanured field drifted, while the other did not. On most farms where the manure was spread in sufficient quantities, it was effective. In some places it was used to good advantage for topdressing the knolls, where drifting was likely to start. Other farmers used straw for the same purpose, some spreading it over the whole field, or spreading it in strips at right angles to the prevailing winds. The use of manure will not solve the problem, because there is not sufficient manure to cover the drifting fields. Secondly, since it is fibre that is required the manure should be spread fresh, and weed seeds would also be spread in this way. Thirdly, unless used as topdressing, it holds the soil open and loss of moisture reduces the yields. Straw is plentiful, but, otherwise, has the same limitations as manure. The conclusion is, therefore, first, that manure is effective, but owing to the limited quantity could only be used on small areas; secondly, the straw was more abundant but not so effective, and the danger from spread of weed seeds more than offset the advantage.

Green Manure Crops

A few farmers are ploughing down green crops. One man west of Carman practised this for a few years and, while it seemed to be fairly effective, it was discontinued during war time on account of the cost of seed. Dr. Grisdale said this morning that it had not proved successful on the experimental farms. I do not think, however, he was then speaking from the standpoint of soil drifting. Where drifting is not a factor, ploughing down green manure crops may not be satisfactory. It will hold the soil too open and thus not retain sufficient moisture for the production of profitable crops, but it is better to have half a crop and prevent the soil drifting than to have no crop and the soil blowing away. It is better than straw, because there is no danger from weeds, and when ploughed under does not hold the soil so open. The conclusion is that, where drifting is bad due to loss of fibre, this method may be used to advantage. It will not, however, be as effective as the roots of the grasses.

Cover Crops

In both Souris and Carman districts a few farmers were using cover crops of oats and barley sown in July on summer-fallow for the purpose of controlling drifting. These crops also provided some fall pasture. The difficulty was that in districts where perennial sow thistle was bad, it could not be controlled, because no cultivation could be given late in the season. The most successful cover crop observed was winter rye. This crop not only acts as a cover when the soil is most liable to drift, but also produces a profitable crop of grain. Soils that drift are usually not in a good state of tilth. Winter rye will thrive on poor soil better than any other

crop. The owner of the farm at Rossendale, from which the sandy sample was taken, stated that since he introduced winter rye into his cropping system his farming had been more profitable and the soil drifted less. By doing away with summer-fallowing he also got rid of the one practice that was most destructive of fibre. The conclusion therefore is that, first, in some sections cover crops can be used to good advantage, and secondly, winter rye is the crop that can be used for this purpose to best advantage.

Substitution of Corn for Fallow

In very few cases was corn stubble land found to be drifting. The compact nature of the soil was not conducive to drifting and the stubble seemed to give some protection from the wind. The roots of the corn also supplied some fibre to the soil. The difficulty, however, is that the average farmer has too great an acreage of summer-fallow to make corn a substitute. Then there are also many districts where drifting is bad and the season too short for successful corn production.

Grass Crops

The only time the soil seemed to contain a satisfactory amount of fibre was shortly after it was broken from the prairie sod. It seems, therefore, that if we are permanently to overcome drifting we must return the fibre in a somewhat similar manner to what it was in the beginning.

Two samples were taken at Souris from adjoining farms, while a gale was blowing and the sand was flying so badly that it was painful to be out of doors. The soil on one farm (John Hume's) was not drifting, while just across the road one could not see over a ten-acre field for flying sand. Mr. Hume follows a well defined crop rotation, in which brome grass appears frequently. The sample from a field broken from brome a year ago can be seen to be full of fibre.

Throughout the survey practically every farm which had grass in the rotation was overcoming the trouble to a great extent. The conclusion was, therefore, that for Manitoba the introduction of grass crops into the rotation gave best prospects of control. The difficulty, however, was to get a catch of grass on the drifting lands. This led us to recommend the sowing of grasses on land before the fibre was all used up.

Kinds of Grasses and Clovers

We were unable to find areas where the different grasses had been tried out side by side. We could find where different sorts had been used in different parts of the country but as the soil and climatic conditions were different, the comparisons of these would not be fair. From a scrutiny of from 100 to 200 farms, we found that where brome was being grown practically no drifting occurred, whereas in places where timothy and western rye were used the soil drifted. The legumes were only grown in small acreages and were not in locations subject to drifting.

The conclusion therefore is that brome is the grass crop that should be recommended for drifting soils.

Place of Grass in the Rotation

I was interested in Dr. Grisdale's remarks in reference to rotations. It was my privilege to spend a short time on the Dominion Experimental Farm at Indian Head, Sask. The rotation that always appealed to me was rotation (J)—first year, summer-fallow; second year, wheat; third year, wheat; fourth year, oats and barley seeded down; fifth year, hay; sixth year, pasture. There is one difficulty, however, where this rotation is put into actual operation on the farm; it is almost impossible to get a catch of grass with a nurse crop three years after a summer-fallow. In fact, on some farms where this rotation was being tried out, this difficulty was so great as to cause the rotation to be abandoned.

I believe the following rotation would be found to give better results:—First year, summer-fallow; second year, wheat, seeded brome; third year, hay; fourth year, pasture and break early in July and backset in September; fifth year, wheat; sixth year, oats and barley. It gives the same crops as the other rotations, only that they are in a different arrangement. The objections are the eradication of the brome and the lack of moisture for the crop of wheat after the pasture. The catch of grass, however, would be assured and the wheat would come after fallow and sod-breaking.

Dr. GRISDALE: Do you mean two summer-fallows?

Professor HARRISON: There would only be one straight summer-fallow. The pasture would be broken at the time the hay crop was being taken off the other field. The aftermath on the field that produced hay would be used for pasture the remainder of the season.

Conclusions

The conclusions that we drew from the results of the survey are that the soil fibre is the key to the situation. The conservation of the fibre we already have in the soil and the returning of fibre to the depleted soils is the biggest problem at present in soil management. The fibre may be conserved by the use of farmyard manure, by the ploughing down of green crops and by the growing of fibrous-rooted crops. The fibrous-rooted crop that seems to be the most effective is brome.

Dr. GRISDALE: In going through Manitoba the past two days I saw many fields with most gorgeous crops of weeds. I would like to ask Professor Harrison what effect weeds would have upon maintaining soil fibre, and also if he has attempted to differentiate humus or vegetable matter from the fibre?

Professor HARRISON: Answering the last question first, I might state, that our work in the analysis of the soil is not yet complete. I have just given you the results of the ignition test, which is, as I stated before, not without question and it is certainly not an indication of the amount of fibre, although, I believe the total amount of vegetable matter will have some effect on soil drifting. It is better to have it in the form of fibre than in the form of humus.

Dr. GRISDALE: Can you tell?

Professor HARRISON: You can tell if it contains fibre by the eye. We probably did not go into this just as fully as a soil expert would, but where we could see the grass roots in the soil there was little or no drifting taking place.

Answering Dr. Grisdale's other question, I would say that the ploughing down of weeds would return some fibre to the soil, but it is a practice I would not care to recommend as the loss from the spread of weed seeds would probably be nearly as bad as the loss from the soil drifting.

Professor BEDFORD: Did you find very much trouble in the eradication of brome grass on the farms you visited?

Professor HARRISON: Practically none. In some fields plants of brome grass could be seen growing with the grain, but the farmers said it did no harm. In most places a little brome in the soil would be very useful in helping to prevent the land from drifting.

The question has been asked what about its eradication in the lower spots in the field. Our experience in growing brome grass in a limited way on the Manitoba Agricultural College experimental field, where we have a heavy clay loam soil and a large amount of moisture, is that we can completely kill it out in one year by breaking and backsetting.

The CHAIRMAN: I want to suggest that the men who are most intimately interested should have a little private meeting to consider the best way of differentiating, by a simple test, between what is vegetable matter and what

is called fibre. I think that is not clear. It looks to me that if the amount of live, tough fibre, which seemed to be the difference between soils that do drift and others that do not drift was comparatively small, that might help us to understand how much fibre was necessary and how long it would endure in a fibrous state, that is, a holding condition.

Professor WYATT: I know of no specific or simple way in which you could distinguish quantitatively between organic matter and the material which Professor Harrison refers to as "fibre." I prefer to call all vegetable matter in the soil organic matter; that is our general term. There is, however, a method of distinguishing between the active and inactive organic matter. By determining the amount of organic carbon and organic nitrogen we are able to use the relation or ratio of the two as an index to the activity or organic matter. Even though this method indicated that the organic matter of the soil were fresh, it would not tell you the amount of fresh plant rootlets, and I take it that Professor Harrison means fresh plant roots when he speaks of fibre.

For active organic matter the percentage of carbon to nitrogen is proportionally higher than is the case with the inactive organic matter, and with the process of decomposition the carbon is lost relatively faster than the nitrogen; thus, when the carbo-nitrogen ratio is narrow it suggests that the organic matter has passed the stages of most active decomposition. There is, of course, the means of merely making observations of organic matter. There is also microscopic examination. Either of these will tell you whether you have fresh or decayed material. It will not, however, tell you the amount of the relationship. The method used by Professor Harrison with respect to determining the loss of ignition, and using these results as an index of the fibre content, is open to objection for the following reasons: First, any sort of organic matter will be oxidized by ignition, just the same as the fibre or fresh plant roots, but equal amounts of organic matter may have decidedly less binding power upon the soil particles than the fibre has. Second, ignition does not always serve to determine even the amount of organic matter in different types of soil, *e.g.,* many of the fine textured soils upon ignition may indicate the presence of considerable organic matter due to the tenacity with which they retain moisture at ordinary temperatures but which is given off before reaching the ignition point; and still a determination of the actual organic content may reveal amounts distinctly insufficient to account for the loss caused by ignition.

I would like to bring this fact before you for consideration, that the results offered by Professor Harrison are very significant, in that they show, in practically every instance, for the same type of soil, that where blowing occurred there was from one to two per cent less loss upon ignition; also that one of the sandy loam soils which had an abundance of brome grass roots did not blow, and that it lost only 6 per cent upon ignition as compared with one of the clay loams, with a loss of 12 per cent due to ignition, which blew badly. It would seem that the condition of fibre rather than the loss caused by ignition was of greater importance in preventing blowing.

Fundamental Principles of Soil Fertility

BY

PROF. R. HANSEN

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SUCCESSFUL agriculture depends upon the fertility of the soil, and permanency in agriculture depends upon the maintenance of the soil's fertility.

In new agricultural countries, the usual procedure is to first develop crops and cropping systems best suited to the area. The objects are big yields, quick returns and especially cash returns. Generally new settlers come in with but little capital, hence the common practice is to mine the land. This practice is not without some justification. It means development and puts a sturdy lot of farmers on the land. Generally speaking those who come in to get rich quick fail, and are replaced by the real farmer. The law of the survival of the fittest operates.

Famines due to Depleted Lands

But there are certain dangers, and we should not be unmindful of the fate of some of the older agricultural countries. The famines in China, in India and in European Russia have been due mainly to depleted lands—lands that were once fertile and productive, and which have now been abandoned or which yield but small returns. The average yield of wheat on the black soils of Russia is about eight bushels per acre. In the New England States we have examples of soil depletion and abandoned farms that once produced abundantly, and which are now allowed to go back to nature to heal.

Principles of Soil Fertility

The principles which govern the maintenance of soil fertility deserve careful study. Science tells us that all of our agricultural plants require as food ten essential elements. Three of these, carbon, hydrogen and oxygen, are derived from air and water, and they constitute 95 per cent of mature plants. The remaining seven, constituting 5 per cent of mature plants, are derived from the soil. These are phosphorus, potassium, nitrogen, sulphur, calcium, iron and magnesium. Nitrogen is an exception, in that leguminous plants, when inoculated, have the power of using the nitrogen of the air.

In order to show the relative supply of the seven elements in the soil and the demands of the crop for them, the following table is submitted.

TABLE I.—RELATIVE "SUPPLY AND DEMAND" OF SEVEN ELEMENTS*

Essential plant-food elements	Pounds in 2 million of the average crust of the earth	Pounds in 100 bush. of corn (grain only)	No. of years' supply indicated
Phosphorus	2,200	17	130
Potassium	49,200	19	2,600
Magnesium	48,000	7	7,000
Calcium	68,800	1¼	55,000
Iron	88,600	1½	200,000
Sulphur	2,200	¼	10,000
Nitrogen in air	70 million lb. over one acre	100	700,000

*Hopkins, *Soil Fertility and Permanent Agriculture.*

The acre of land, ploughed to a depth of 6⅔ inches, is taken to weigh 2,000,000 pounds, and the calculations are made upon this basis. For the purpose of computation, a yield of 100 bushels of corn to the acre is assumed, not at all an infrequent yield in the corn belt. Based on wheat, the results would be similar. This table emphasizes several vital points. First, we find that calcium, magnesium, iron, sulphur and potassium occur very liberally in relation to the amounts required. Certain soils, notably peat, are deficient in potassium, and the application of potassium salts gives increased yields and profits. On most normal soils, however, there is sufficient potassium, and the problem is to make the insoluble potassium available to plants. This is accomplished by providing liberal amounts of organic matter, such as farm manure or crop residues, the decay of which liberates the potassium.

Contents of Soils

In old worn-out soils potassium salts, such as kainit, are frequently used, to the ultimate ruin of the land. Potassium salts have a stimulating effect, hastening the availability of plant food and making possible greater crops temporarily, but providing for no return of the materials taken away.

The earth's crust contains on an average about 2,200 pounds of phorphorus to the acre. Only the richest soils approach this amount; in normal soils the phosphorus content may run from 1,000 to 2,000 pounds. On the basis of 30-bushel crops of wheat, this would suffice for from 100 to 200 years, if it were possible to remove down to the last pound, which, fortunately, we cannot do.

Because of its importance to soil fertility, organic matter deserves consideration. Organic matter is supplied to the soil in several ways: (1) by turning under crop residues, as stubble, straw, corn stalks, etc.; (2) green manuring, for which purpose leguminous crops are most commonly used; (3) pasturing, the most economical method of supplying manure, since the cost of hauling and spreading is saved and the losses due to fermentation in the manure pile are avoided; (4) spreading manure, the benefits of which are fully appreciated in the older agricultural regions.

In a ton of wheat straw there is enough nitrogen to make 7·1 bushels of wheat, enough phorphorus to make 6·7 bushels of wheat and enough potassium to make 69·2 bushels of wheat. This does not mean that if we applied a ton of straw we could expect this increase in yield; it is simply stating that we return that amount of material, and the soil would be that much richer. In one ton of farm manure there is enough nitrogen to make 7·1 bushels of wheat, enough phorphorus to make 12·5 bushels of wheat, and enough potassium to make 30·8 bushels of wheat. I think, however, the value of farm manure is fully appreciated.

Value of Organic Matter

Organic matter turned under is the source of humus to the soil. Most of the facts about humus are generally known. It improves the tilth of the land, increases the capacity to hold moisture, holds the soil together to prevent drifting, provides a certain amount of plant food, and aids in the liberation of plant food. The actively decaying organic matter is all important in making plant food available, and we distinguish between actively decaying organic matter and the humus in this regard. I use the word "humus" although I know it is out-of-date, but we generally regard humus as being the residual matter after the organic matter has decomposed; it is the portion which is resistant to decay, though it does slowly decay, especially through cultivation. It is the actively decaying organic matter which, in the process of decay, produces certain acids which, in turn, dissolve or make available certain plant food. This is one of the benefits secured from the application of manure or the turning under of green manure. In the corn belt I have seen sweet clover standing as high as a horse's head ploughed under for the purpose of soil enrichment.

Bacteria and Soil Fertility

The decay of organic matter is brought about by the bacteria and it might be well to mention here that we have much for which to thank our infinitely small friends in the soil. The bacteria digest the remains of plant and animal life that come upon the soil, releasing much of the bulk to gases and water vapour, and leaving the residue, humus, in the soil; thus the earth does not become cluttered up with all this waste matter. In this decay process, as mentioned before, acids are created which make plant food available. The nodules on leguminous plants are caused by bacteria, making possible the utilization of nitrogen from the air. This nitrogen, and, in fact, all soil nitrogen occurring as plant or animal remains, cannot be utilized by succeeding crops until it has gone through preparatory processes. First, it is broken down to ammonia, then built up to nitrite, and then to nitrate, the form in which crops take it from the soil. These processes depend entirely upon the bacteria, and these are facts we should fully appreciate. While the bacteria have been widely condemned for what they should not do, we should give due credit for the good things they do accomplish.

Losses of Nitrogen

It has been determined by Dr. Frank T. Shutt, after analyses of soils at Indian Head, that cropped soils had lost approximately one-third of their nitrogen and one-third of their organic matter. Donaghue, working in North Dakota, found the same thing. In Saskatchewan, soils cultivated for some time were compared with the virgin soils close at hand. In the ploughed acre, to a depth of 6⅔ inches, the loss in nitrogen due to cultivation was something like 2,200 lbs., which represents, of course, a tremendous amount of organic matter.

Nitrogen

The earth's crust contains on an average but a trace of nitrogen. Productive soils of the corn belt contain about 8,000 pounds per 2,000,000 (*i.e.,* the acre 6⅔ inches). The amount varies greatly. Eight thousand pounds would be enough for 200 years of 30-bushel crops of wheat, but a peculiar fact about nitrogen is that the crops removed account for but a small amount of the actual measured losses. Tillage operations, especially the summer-fallow, cause its dissipation.

In considering nitrogen, the question of organic matter should be considered in conjunction. Nitrogen in the soil occurs chiefly in the organic form; organic matter is the chief source of nitrogen. For general agricultural crops it does not pay to use commercial nitrogen. Nature supplies a cheaper source in the way of leguminous crops.

The advantages of growing leguminous crops are widely known. These include the facts that, (1) when inoculated, they possess the power of utilizing the nitrogen of the air; (2) that they are widely used for green manuring, because of the amounts of organic matter they supply, and the readiness with which they decay in the soil owing to their succulence.

Innoculation of Legumes

Several of these points require further explanation. First, that unless inoculated, unless nodules are produced on the roots, leguminous plants behave as do ordinary farm crops, living entirely at the expense of the soil's nitrogen. Second, the fact determined by the Illinois Experimental Station that, in normal soil, inoculated clover derives about two-thirds of its nitrogen supply from the air and one-third from the soil, and in the plant two-thirds occurs in the tops and one-third in the roots and stubble. It is therefore apparent that, if cut for hay, there is no gain in nitrogen for the soil, but an even split. This is, of course, an advantage over ordinary crops, which take their entire supply from the soil. But every ton of alfalfa or sweet clover tops contains 40 to 50 pounds of nitrogen, so that every

ton turned under as green manure is equal to 4 or 5 tons of barnyard manure (barnyard manure contains ten pounds of nitrogen per ton) as far as the nitrogen is concerned. The organic matter is also important in that it supplies humus and makes plant food available.

Crop Rotation and Fertility

Crop rotations have a bearing on soil fertility, and I only want to touch on several facts. At Rothamsted, wheat grown in a rotation without fertilization has yielded 25 bushels as an average of 60 years. In a field grown continuously to wheat the average yield was 12·9 bushels. Barley in rotation averaged 24·7, whereas continuous barley averaged but 14·8 bushels. Crop rotation makes possible greater crops, and hence makes greater draft of plant food from the soil. It is the most efficient way of depleting the soil of its fertility. It has been a common error to believe that crop rotation fertilized the soil and made increased production permanently possible. Such, however, is not the case. Where the rotation alone gave 25 bushels of wheat, fertilization increased the yield 34.6 bushels; with barley the rotation gave 24.7 bushels without fertilizer and 38·9 bushels with fertilizer. Turnips in the same rotation yielded thirteen-fold when fertilized over the unfertilized as an average of 60 years.

This evidence is not to be construed as being opposed to crop rotations. Rather it is in its favour. It is our purpose to produce large crops, and, in order to do so, we must expect to draw proportionately upon the soil. Our concern is to see that the soil lacks nothing that it needs to produce maximum yields. To return to the soil the things that are removed in such amounts as will limit crop yields, and to supply any deficiencies that may exist should be our aim.

Acidity and Alkalinity of Soils

Aside from deficiency of plant food, two conditions frequently exist in soils to the detriment of crop production. These are soil acidity and alkalinity. Acid soils are most commonly found on the older worn soils in the humid sections, due to the gradual leaching out of the limestone. Soils of limestone origin are frequently acid or sour on top, though underlain with limestone rock. The cheapest and most effective correction is to apply finely ground limestone, at the rate of one or two tons per acre, depending upon the degree of acidity.

Alkali soils occur most frequently in the arid and semi-arid regions, where the alkaline salts have accumulated on the surface because of the high surface evaporation. The most practical cure for soils that are not too alkaline is to grow crops which are alkali resistant, such as western rye and brome grass and sweet clover, all of which withstand higher concentrations of alkali than the grain crops. Heavy applications of manure will also be found helpful in destroying the effect of alkali.

Soil Corrections

To sum up, then, the things which make for maximum production and at the same time conserve the fertility of the soil with the view of permanency, we have to consider: (1) Acid and alkali soils. For acid soils, limestone is the best and cheapest corrective. For alkali soils heavy application of manure where practicable and the growing of alkali resistant crops, as brome and western rye grass and alfalfa or sweet clover, are recommended. (2) The addition of such materials to the soils as are removed or lacking to the extent of limiting crop yields. (3) Suitable rotations. I need only mention that now, as it is a matter that will be considered in another paper. (4) The return of organic matter to the soil. The greatest soil problem in Western Canada aside from moisture is no doubt organic matter, for in it are bound up several important considerations, *i.e.*, the return of nitrogen, the availability of plant food, the return of humus, the latter factor bearing upon the question of tilth, the water-holding capacity and soil drifting.

Generally speaking, soil men are regarded as being pessimists. They do not see the wonderful harvests we reap but see only the losses of phosphorus, of nitrogen and of potassium from the soil.

Soils at Present Rich and Fertile

But we have reasons to be optimistic. Our soils at present are rich and fertile, and, for the present at least, other considerations, such as the importance of soil moisture and the development of our lands, may be of paramount importance. But we cannot afford to be too optimistic. If there are dangers ahead we should be aware of them. As a conservation measure, I would recommend a nation-wide survey of our soils, such as is being conducted by the Bureau of Soils of the United States Department of Agriculture. If the soil is our greatest resource, as no doubt it is, we should know our strength or weakness. The merchant in his business stops occasionally to take a stock inventory to establish his assets and liabilities. This is the purpose of such a survey. In regard to soil drifting, many lands have been broken up which never should have been, and perhaps many more will be which should not. These lands should be classified, with the object of checking this evil which threatens our good lands as well. It is the only way in which we can define the areas; in that way only can we stop the evil and alleviate conditions as much as possible.

The CHAIRMAN: Do I understand Professor Hansen to say he found as much as 2,200 pounds of nitrogen lost per acre between cultivated lands and the original prairie around Saskatoon?

Professor HANSEN: Yes; that was taken as an average on six soils. Six virgin soils were compared with six cultivated soils, which had been cropped; one was under crop twelve years and the remainder mostly 24 years. The average loss was 2,200 pounds for the ploughed acre, 6⅔ inches.

The CHAIRMAN: Was there any other channel of loss; twelve years' removal of crops should not take anything like 2,200 pounds of nitrogen from it, should it?

Professor WYATT: The loss of 2,200 pounds of nitrogen would be about equivalent to twenty tons of organic matter. That gives an idea of how much organic matter had been lost. That is, I think, more organic matter than we have in some of our districts in the west.

Professor HANSEN: For comparisons we had to go to the virgin soil and then as closely as possible to a cultivated field. We have no accurate knowledge of whether the two were comparable 12 or 13 years ago, but we have compared in every case the cultivated with the virgin soil as nearly as possible and taken the average condition; in every case it measured a loss and we averaged the loss. All we can say is we have an indication of the loss of that amount, but we do not maintain it is the actual figure. We can only show the tendency. Undoubtedly the loss is greater than we can account for in the crops and that, of course, is due to our cultural methods.

The CHAIRMAN: I can understand the loss of organic matter, but if there would be more nitrogen actually lost out of the soil than went into crops, where did it go to?

Professor HANSEN: Generally we know that nitrogen may be lost in one of several ways, aside from that removed in crops. Under ordinary conditions, the organic nitrogen in the soil is converted to nitrate, which is soluble in water, and which may be removed in considerable amounts by leaching or surplus run-off. The losses from this source are, of course, greater in humid regions. In wet soils de-nitrification may occur, the result being that through bacterial action, the nitrates are changed back to ammonia or free nitrogen gas and lost into the atmosphere. This loss would be appreciable only in water-logged soils. Under the conditions here, that is, excessive tillage of the summer-fallow, it is

possible that the organic nitrogen is broken down to ammonia too rapidly in the soil for the nitrification process (*i.e.*, the conversion of ammonia compounds to nitrite and then to nitrate), and that nitrogen may be lost as ammonia. This is only a possibility and seems hardly probable. There is another possibility that nitrogen may be lost as ammonia through hydrolysis in the soil, being favoured by the high content of basic substances in our soils. Further work should be done regarding the amounts and causes of the losses of nitrogen from our soils.

The CHAIRMAN: May I ask Dr. Grisdale if they used sweet clover in green manuring? It is known to introduce perhaps 40 to 50 pounds of nitrogen per acre. The point I want to make now, however, is, would it not be a good sort of plant to incorporate in the soil because of its fibrous conditions, its enduring qualities? Ploughing under might not be advantageous, or economic from a profit-making standpoint, but it might have value in helping soils to recover in subsequent years.

Dr. GRISDALE: I have no doubt that sweet clover could be used for this purpose; but, where you can grow sweet clover successfully and know how to handle it, it would be a shame to turn it down for manurial purposes. It would be much better to use it for animal food and then return the manure. As Professor Hansen has stated, legumes add a considerable amount of fibre and nitrogen in the soil which would serve the purpose of nourishing the soil and helping it to become wind resistant. I therefore think while sweet clover would be a good crop for the purpose, since it has to be seeded down like any other clover or grass, it would mean a pretty difficult, or rather, an expensive, way of getting the green manure. It is not like peas or vetches, that could be grown without any trouble, comparatively speaking, and turned under. In the peas and vetches we also have the leguminous qualities of the sweet clover, so that, in my opinion, it would not be advisable as a green manure or for fibre, except in the way I have mentioned.. In that connection, there is another observation that may be worth referring to. Where moisture is the limiting factor in crop production in Western Canada, the legumes requiring such a large amount of moisture, we perhaps would be producing fibre at a very heavy sacrifice of moisture which we might need later on for the growing of wheat.

Professor HANSEN: I do not want it to be understood I was recommending a rotation including sweet clover; I was merely advocating the principles of soil fertility. The importance of those principles has descended to us from the older agricultural regions, where they, too, have been obliged to resort to things of this sort. I wished to show the reason why those things should come about. In the corn belt, sweet clover is rapidly replacing red clover and red clover has been grown a great deal through that country as a soil improver. The reason is the greater bulk and also the greater succulence of sweet clover. It decomposes more readily in the soil and makes plant food available. It is a method of renovating some of the older cropped soils.

Soil Drifting in Southern Alberta

BY

W. H. FAIRFIELD

Superintendent Experimental Station, Lethbridge, Alta.

IN dealing particularly with soil drifting as we have experienced it in southern Alberta, let it be understood that this is not the only place it has occurred, but there was perhaps a larger area of crop destroyed this year by soil drifting in this portion of Alberta than in any other one place on the prairies, and it would be better to confine myself to conditions as I know them from personal observation.

The boundaries of the area badly blown could be described as follows: Beginning on the west about the fifth meridian in the neighbourhood of Pincher Creek and extending eastward or slightly northeastward to about Grassy Lake on the Crowsnest branch of the Canadian Pacific Railway, and Retlaw on the Suffield-Lomond branch of the same railway, a distance of some 90 to 100 miles. This comprises an area of 40 to 50 townships, or, roughly, a million acres of land, one-half or three-quarters of which is under cultivation. Over this area the damage done by the wind varies from 2 or 3 per cent up to over 75 per cent of total loss of crop in the worst localities. It should be pointed out that, with a few insignificant exceptions, the soil in this area is not light but a good chocolate loam. The lighter soils referred to occur on the eastern extremity of the affected area. As an actual fact, the most extensive damage occurred just to the west of Lethbridge where the soil would be classed as anything but a light sand.

In the area described there has, in my judgment, been 75,000 acres of crop absolutely destroyed by soil drifting.

This land is all settled, and from it excellent crops have been obtained. Between Lethbridge and Macleod improvements on the farmsteads are above the average, good buildings obtain, and houses with modern conveniences, such as electric lights and water systems, are not uncommon.

Primary Cause of Soil Drifting

The primary cause of the extensive soil drifting that we are experiencing to an increasing extent from year to year is due to summer-fallowing. On account of our light rainfall, summer-fallowing is a necessity, and never can be entirely eliminated from any successful system of farming that may be introduced. The summer-fallow is a necessity in the drier regions because we do not get enough rain each season to produce crops, and, by preventing vegetation growing for one summer, a large amount of the moisture that falls goes into the soil and is carried over in our close subsoils to the following season to supplement the rainfall during the season that the crop is growing. By this system of farming it has been possible to raise cereals in the drier portions of the Prairie Provinces that would otherwise not make satisfactory returns.

When the land was first broken up, the large mass of vegetable matter, in the form of root fibre, in the soil prevented it from being affected by the heavy winds, but, by continuous cultivation, especially where the land was left so often as a bare fallow, this vegetable matter was used up, and the physical texture of the soil soon changed, leaving it in a condition that would readily drift. The drifting is noticeable first on light sandy soils, but in time it is apt to occur on all kinds of soil.

This trouble has not been confined to Western Canada, but has been experienced in many of the states on the plains area lying directly east of the Rocky mountains. It is interesting for us to observe how they have met the difficulty, and, in a great many cases, satisfactorily overcome it. Their methods, where they succeeded in doing so, have been based on the intelligent use of corn or some of the quick-growing sorgums.

Proposed Methods of Control

A brief outline of the methods of control that might be successfully adopted for our conditions in southern Alberta and southwestern Saskatchewan could be given as follows:—

First: Irrigation. Where it is possible to obtain water for irrigation it is obvious that the problem of soil drifting could be entirely eliminated. It would not be necessary to resort to summer-fallow, there being no place for summer-fallow on an irrigated farm, as there is no need to conserve moisture. There would be large areas devoted to alfalfa and other hays, diversified farming would at once be begun, all forms of live stock could be profitably maintained, and a permanent, reliable revenue would be annually obtained from all land irrigated.

Second: Although irrigation is a perfect cure for the trouble where it can be obtained, there must always remain a large proportion of the land unirrigated, probably 90 or 95 per cent. On this land it will be necessary to inaugurate community effort, on the importance of which too much stress cannot be laid. For example, one man may farm his land in such a way, even a summer-fallow, that it is not drifting; if the land on the farm to the west of him starts to drift, it will blow over on to him, and soon get his land in the same condition and so the trouble, or, to be more literal, the soil goes merrily along.

Third: Our climatic conditions are not the same as they are in the United States where soil drifting has occurred. We cannot raise corn as a money crop; that is, we cannot ripen the grain, so that we cannot adopt methods exactly similar to those used in the United States. We will, therefore, have to work out for ourselves the details that will fit our conditions.

Fourth: A change to diversified farming is necessary. We will have to reduce very materially the amount of land on each farm that is devoted to the growing of cereals, and adopt a rotation where a portion of the land is kept seeded down to grasses, from which in wet seasons hay will be obtained, and in all seasons some pasture. With this method the live stock holdings will increase, for they will be required to consume the forage and pasture crops. By the carrying of live stock, it will be possible to have more manure available to apply to the land to help restore the humus in our soils, the depletion of which is so readily indicated by the soils starting to drift.

Fifth: The introduction very generally of winter rye to sow on our summer-fallow, for the reason that this crop occupies the land at the period of the year when soil drifting is most likely to occur, *viz.*, during the late winter and early spring months.

Sixth: A frank recognition of conditions as they exist. This will mean that farmers generally in the drier areas will have to realize that it will not be safe for them to devote their entire land holdings to the production of spring grain, as has been done in the past. The duty will devolve upon the authorities to inaugurate a comprehensive soil survey. When this is done, it will be possible to determine the localities where the land is too sandy and light to be suitable for general farming, and such areas may be seeded back to grass for pastoral purposes.

Dr. Grisdale: Has irrigation any detrimental effect on alfalfa seed production? I know in parts of California where they started irrigation they had a great reduction in yield of seed.

Mr. Fairfield: The production of alfalfa seed is as yet very limited. Practically all of the alfalfa seed is produced on dry land with alfalfa planted in rows. Practically without exception they are unable to raise seed on alfalfa planted in the ordinary way in the irrigated area. It grows too much to stem. Alfalfa grown in rows in the wheat field produced nearly always a good or a fair crop of alfalfa seed, and that is cut along with the mustard seed.

Mr. Pearce: Are you familiar with Mr. Barton's experiments in producing alfalfa seed?

Mr. Fairfield: Mr. Pearce refers to the work of Mr. Barton, of Brooks, in raising alfalfa seed. In 1918 he had two or three acres of alfalfa, planted in the ordinary way and irrigated, that produced a marvellous yield of alfalfa seed, about 16 bushels to the acre. This is an exceptionally high yield, and I think Mr. Barton himself admits it is the only time he has ever seen that. I am only speaking in generalities when I say alfalfa seed is not produced on irrigated land.

Dr. Grisdale: What about the quality of potatoes?

Mr. Fairfield: The quality of potatoes on irrigated land appears to be quite as good as on dry land. Some of the farmers on irrigated land do not have potatoes of as good a quality as those on dry land, but, with reasonable experience and care, as good potatoes can be grown on irrigated land as on dry land.

Dr. Grisdale: I presume that the advocates of irrigation will admit that in spite of the abundance of water, the soil will gradually lose its fertility unless some means are taken to avoid it. Would one of the advocates give us a little light on the subject?

Mr. Fairfield: We have always felt, in the Lethbridge district, in regard to fertility on the irrigated land, that economic reasons would take care of that. Alfalfa is much more profitable to grow than cereals, and, to dispose of alfalfa and other hays profitably, we must have the live stock. The increase in our live stock holdings would mean that we would have a great deal of manure.

Dr. Grisdale: You found immediate results from the application of farmyard manure?

Mr. Fairfield: Yes.

Mr. Pearce: I understood from Dr. Grisdale's address that there was very little difficulty in most of that country in getting manure. About eight miles from Calgary, manure is piled up to a considerable depth. That manure is from the stockyards and, as you know, is not composed largely of straw, because they are pretty economical of bedding in the stockyards. It is an utter impossibility to get that to rot. Very little farmyard manure about the farms in Alberta and Saskatchewan will rot at all. With the aid of irrigation it may be rotted. I am going to make a suggestion with regard to the application of fertilizer. I was farming to the extent of 30 or 40 acres, and I put all my fertilizer on to the land in liquid form. I drew the manure from the stable at Calgary and put it in a reservoir, ran water into the reservoir, and ran the liquid manure out from the reservoir on to the land. I found it very satisfactory, and the astonishing thing about it was that, speaking conservatively, there was not over 5 per cent of what I put in that reservoir that I had to clear out; it all went out in the form of liquid. Of course, the manure I put in was better than the average, for the reason that it was all horse and cattle stable manure. The finest irrigation system I think there is in Canada is that of Messrs. Hiram Walker & Sons, in the neighbourhood of Windsor, Ont. They use all the fertilizer in liquid form on the land and it is a model farm in the way of fertilizing. The liquid can be pumped up and distributed over the land; it can be done cheaply and is most efficient.

Professor CUTLER: I would like to ask if there are known cultural methods that will help to overcome our present serious difficulties of soil drifting or blowing. We have this problem before us to alleviate at once, if possible. Is it known whether, for instance, the rod cultivator has been a success? I believe it has been tried in the Lethbridge country. Also, if any cultural methods have been employed that will help to remedy some of the difficulties that are surrounding the farmer who finds his soil blowing.

Mr. FAIRFIELD: Speaking broadly, cultural methods will lessen very materially the chances of blowing from our summer-fallows, but I do not believe that they will entirely eliminate it. Professor Cutler spoke of the rod cultivator. We have a very good example of what good cultural methods will do in the Noble Foundation at Nobleford. It was in the fall of the year that the bad drifting took place. The principle that Mr. Noble has followed in his cultural methods is this: He will not plough his land except when it is moist. To succeed in doing that, he discs his land and cultivates in the spring. He plants only, or practically only, on summer-fallow, so that he has his seeding down in about a little over two weeks after the frost goes out in spring. He then cultivates all the land he is to summer-fallow, and, by firming that surface mulch, destroys the weeds and retains the moisture, so that the land will be moist when he ploughs it for the fallow. He ploughs his land usually in late May and early June, and, instead of cultivating that with any kind of implement that will pulverize the surface of the land, he uses implements that will destroy the weeds and bring the small lumps and so on to the surface and not powder the surface any more than necessary. He practically eliminates the use of the ordinary harrow entirely. The implement that he prefers to use is the rod cultivator, which is about 12 or 14 feet long, on which he puts from six to ten head of horses, depending on the size of the implement. The rod cultivator first devised was a stationary rod, of about ⅝-inch round steel, that passed through the ground two or three inches below the surface. This has been improved on by using a one-inch-square rod, which passes through the ground in the opposite direction it is going in; this brings up the lumps and rubs off all weeds and all kinds of vegetation. He assured me that he has been able to destroy Canada thistle with this implement. Near the town of Nobleford he has between six and seven thousand acres of crop in this spring. I drove by his place on the 9th of June, the day after a severe storm, and, with the exception of about 200 acres on the west side, where some of his neighbours' soil had come over, all his land was whole. It is therefore safe to say that there are cultural methods that will greatly alleviate the possibility of soil drifting, but on the other hand, I do not believe that cultural methods alone will solve the problem. I am not sure that Mr. Noble will be able to hold that land more than a year or two longer under present conditions.

Professor HANSEN: I would suggest that at least a few illustration stations should be selected in the area where the drifting has occurred, in order to get at the problem, if there is any possible way of reclaiming this land. We must not only be able to advise but must show it is practicable. I think if there was something like that, and the farmers were shown, something could be done along that line.

Urgency for Further Irrigation Development in Southern Alberta

BY

G. R. Marnoch

President Lethbridge Board of Trade, Chairman Irrigation Development Association, Vice-President Western Canada Irrigation Association

FARMING under irrigation has proved so successful and profitable in the areas east and south of Lethbridge where it has been increasingly practised during the past fifteen to twenty years that one might wonder why the demand for the extension of the use of the mountain stream waters has not hitherto been more clamant. The reason is simply this—that grain growing on dry land, in spite of the drawbacks of an erratic climate, was, up till a few years ago, apparently more profitable.

In the opening up of a new country the situation may always be described tersely in the terms that land for some time is always relatively cheaper than labour. Quick development, or, as wiser men put it, quick exploitation of land, leads to the extensive use of land, with labour as the limiting factor. It took us some time to realize that there was another limiting factor—moisture. And now we realize that we have still another factor of limitation in the soil drifting, which has been a growing problem in the last few years all over Western Canada, which this year (1920) became so serious in parts of southern Alberta as to be disastrous in its effects.

Farming under irrigation, while it must make agricultural operations more intensive, leading to the use of less land per unit of labour, will provide against the lack of moisture, and will provide means absolutely to control soil drifting—further than that, it inevitably leads to the maintenance of the fertility of the soil, a matter that has received, unfortunately, far less than the attention that is its due in Western Canada.

Replace the Humus

We have been prone to think that our soils had illimitable quantities of nitrogen, phosphoric acid and potash to draw from; and while this may largely be true if the top soils stay with us, it certainly is no longer true when these rich soils blow away. The one sovereign remedy against this is the replacement of humus in the finely-tilled soil. And there is, practically speaking, but one means for the provision of this humus available for us, and that is cow-dung. We cannot have that without cows, we cannot have cows without pasture, and we certainly cannot have many cattle on the farms unless we have irrigation to provide the necessary pasturage and feed. Then again, one of the most profitable crops under irrigation is alfalfa, which is in itself both a humus-builder and a nitrogen provider.

Remedy Close at Hand

It so happens, very fortunately, that in the area where the effects of soil drifting have been most severe, the remedy is closest to hand. The Lethbridge Northern Irrigation District, which will draw its water from the Oldman river—an all-Canadian stream—is absolutely prepared to proceed at once with construction work just as soon as financing can be arranged. Every detail has been carefully studied by the Reclamation Service of Canada. At the instance of the Alberta Government the proposed project has been reported upon by George G. Anderson, an irrigation engineer of continental repute, having great practical experience both in the United States and Canada, who thoroughly understands all the engineering,

financial, agricultural and human elements involved. The water supply at the very lowest stream measurements over a long series of years is guaranteed. There are no engineering works of any magnitude necessary, and the engineer of the district, H. B. Muckleston, has had long experience as assistant chief irrigation engineer with the Canadian Pacific Railway Company.

The farmers who own the 110,000 acres that will be irrigable under the project are most anxious that construction should be proceeded with at once. Estimates of cost, generously conceived even at the present prices for labour and materials, indicate that when tenders are called for, they will show that the work can be carried through to a finish at a capital cost of less than $50 per irrigable acre. That the farmers will amply be able to pay the interest, and repay the capital on this expenditure during a term of say thirty years, is clearly demonstrated by the results shown in the following:—

COMPARATIVE RESULTS IN CROPS GROWN ON DRY LAND AND IRRIGATED LAND AT THE EXPERIMENTAL FARM, LETHBRIDGE, GIVING YIELDS PER ACRE

—	WHEAT (Marquis)		OATS (Banner)		BARLEY (Sweet Chevalier)		PEAS (All varieties)		POTATOES (Irish Cobbler)	
	Dry Bu.	Irr. Bu.	Dry Bu.	Irr. Bu.	Dry Bu.	Irr. Bu.	Dry Bu.	Irr. Bu.	Dry Bu.	Irr. Bu.
1908	29	43	80	88	55	61	19	19	92	235
1909	31	40	56	77	44	69	19	19	159	605
1910	11	23	21	68	12	54	12	33	103	521
1911	Hailed*		Hailed*		Hailed*		23	39	356	508
1912	28	50	77	145	41	77	31	62	296	501
1913	25	53	73	115	50	93	41	42	195	483
1914	24	54	49	113	25	90	19	52	400	495
1915	63	94	143	81	86	80	53	50	283	447
1916	48	71	118	157	64	79	46	37	475	530
1917	28	48	66	128	40	82	23	48	157	465
1918	14	62	24	104	17	91	16	48	93	505
Average 11 years	30	53	70	108	43	78	27	41	237	481
Increase due to irrigation	23 bush.		38 bush.		35 bush.		14 bush.		244 bush.	
ncrease due to irrigation	77 p.c.		54 p.c.		81 p.c.		51 p.c.		103 p.c.	

*Not included in computation of averages.

In all cases (except potatoes), the results are obtained from 1·60-acre plots. On this account the yields are higher than would probably have been the case had the fields been larger. The comparative results are no doubt the same—*i.e.*, the per cent of increase due to irrigation is the same as would have been the case had the fields been larger. On the dry land the crops were in all cases planted on *summer-fallow* land. On the irrigated land the grain crops were grown on land that had raised a hoed crop of some kind the year previous, and the potatoes were usually planted on grain land.

Results From Alfalfa and Hay Grown With Irrigation

Comparative yields of alfalfa and timothy are not given, for the reason that the returns from these crops have been so low on the dry land that it was hardly thought worth while to tabulate them.

On the irrigated part of the farm the average yield of cured alfalfa for the past ten years has been considerably over four tons per acre. Some seasons it has exceeded five tons per acre. This is the weight of the hay as it was hauled to the barn or stack. There are no reliable statistics available giving the average yield for the district but it is probably in the neighbourhood of three tons per acre. Individual farmers of course obtain more than this. Timothy being cut but once yields less. From one and one and a half tons to over two tons per acre is the usual harvest.

Irrigation Will pay

Taking wheat alone as an index, it will be noted from this table that wheat production on "dry" land averages 30 bushels per acre, which, allowing for summer-fallowing half the acreage each year, gives 15 bushels annually, against 53 bushels annually on irrigated land—an increase of 3½ times in production. Even at pre-war prices of around 80 cents a bushel, and cutting down the estimated production to 40 bushels, there would be a gross return of $32 per acre per annum. Or, again, figuring in terms of alfalfa at the low rate of 3½ tons per acre at say $10 per ton, there would be a gross return of $35 per acre annually. So we are talking about a proved profitable business, on soils eminently fitted for irrigation, and in a climate which for fifteen years has not failed to show profitable results.

History of Lethbridge Northern

The Lethbridge Northern Irrigation District is governed by the Alberta Irrigation District Act passed April 10, 1920; this Act governs all irrigation districts in Alberta. Water supply and management fall under the Irrigation Act of the Dominion of Canada.

The district was formed in September, 1919, and three trustees were then elected. The district has its own secretary, and it also has its own engineer and staff. All of its operations are supervised by an "Irrigation Council" appointed by the province of Alberta.

A special Act, also passed April 10, 1920, called "An Act to assist the Lethbridge Northern Irrigation District," provides that the province of Alberta guarantees all first mortgages on the lands included in the district, thus making way for the debentures of the district as a first charge on the lands; and the Act also provides that the province will guarantee interest on the debentures to the extent of two years' interest at any time during the life of the debentures.

Money for Construction

All of the formalities in connection with the issue of the debentures are not yet completed, but it is expected that they will be within a few weeks. It is exceedingly doubtful, however, that a market can be found just now for these debentures; indeed it is almost certain that it will not be possible, in the present state of the financial markets, to dispose of them. The Alberta Government has been urged to provide, in the meantime, as an emergency measure, for advancing funds to enable construction work to be started while the weather is yet favourable; but the answer is not encouraging.

The Alberta Government has opened communication with the Dominion Government with a view to evolving means whereby the Government may collaborate on some plan to finance the district. In the House of Commons shortly before Parliament prorogued, the Minister of the Interior disclosed a sympathetic attitude towards the reception of such proposals; and the result of these communications is awaited with the greatest anxiety by all of the people in southern Alberta, but much more by these farmers who have suffered so great loss from soil drifting, and whose lands fall to be irrigated under the district.

Is Keystone Project

The progress of the Lethbridge Northern is looked upon as the keystone to further irrigation development. The lands now under irrigation around Lethbridge, roughly 82,000 acres, made a gross production record in 1919 of $54.71 per acre; so it is hardly to be wondered at that those other areas to which water may be brought are most anxious for irrigation.

There are three other districts whose lands can be watered, like the Lethbridge Northern, from all-Canadian streams. They are the United District, west of Cardston, 15,000 acres irrigable; the Lone Rock, north of that, 10,000 acres; and the South Macleod, 30,000 acres.

The Dominion Reclamation Service is completing surveys on some of these, as well as on lands around Lomond, Travers, Enchant, and Sundial, northeast of Lethbridge, which may get water for 100,000 acres on an extension of the Lethbridge Northern canals.

In addition to these, irrigation may be carried to great areas south and east of Lethbridge, roughly 400,000 acres, from the waters of the St. Mary and Milk rivers; but these streams are not all-Canadian and the question of the division of the use of the waters is now under discussion and adjudication between United States and Canada before the International Joint Commission. An early solution of this situation is eagerly looked for.

It is curious to the people around Lethbridge, who know so well the benefits of irrigation, that their Government of the province of Alberta takes every step in the direction of helping irrigation development apparently with great fear and trembling. It appears to be hard for the Government to see the vision of a potential productive capacity from 500,000 acres of lands already fully settled by experienced farmers, and over the area of which the continuing fertility of the soil would be assured all through the years.

Earlier Mistakes Rectified

Perhaps this vision is obscured by the earlier mistakes, now happily rectified, that were made both in the management of the great irrigation projects of the Canadian Pacific Railway on their lands east of the city of Calgary, and by some of the settlers on these lands. Some of these grave errors have been publicly acknowledged as such, and some have been recognized in what after all is the best method—a quiet reversal of policy.

With all the safeguards that have been devised for the management of irrigation districts; with the Irrigation Council of Alberta in direct supervision of the farmer-trustees; and by the general overlooking eye of the Dominion Reclamation Service, there is no need to fear that every project will be carefully scrutinized in all its operations; and no doubt need be felt that these public irrigation projects will, very soon after their practical inception, command the sound financial credit to which they will be entitled.

Influence of Windbreaks on Field Crops

BY

NORMAN M. ROSS

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WHEN the question of the effects of windbreaks or tree belts on the growing of field crops is to be considered it is an extremely difficult matter to make any really definite statements other than those based on general observation. So far as I am aware, no scientific examination along the line has ever been conducted in the Canadian prairie regions, and but very little in the United States. In 1911, the United States Forest Service published a bulletin, No. 86, "Windbreaks, Their Influence and Value," by Carlos G. Bates, covering the results of a very detailed examination in Kansas, Nebraska, and southern Minnesota. The bulletin consists of 100 pages, and is very fully illustrated. It is to our knowledge the only work containing official data on this subject as applied to prairie conditions, so that very much of the information which follows has been drawn therefrom. Some extracts are taken verbatim from the bulletin.

Beneficial Features of Wind-breaks Windbreaks may have good as well as detrimental influences on adjoining field crops. The beneficial features are:—

1. Protection from the mechanical force of the wind, checking soil drifting, shelling out of grain, etc.

2. Lessening evaporation, by affecting light winds and breezes which are not strong enough to injure crops mechanically.

3. Holding snow which would otherwise be blown off cultivated land.

4. Increasing the air temperatures in the vicinity of the belts, having somewhat the effect of hotbed conditions.

There are several other lesser advantages, such as protection of stock, forming obstructions to the spread of such weeds as Russian thistle and tumbling mustard, the aesthetic value and also the direct return of wood products, such as posts and fuel, which, however, do not directly affect the growing of field crops.

This may affect crops injuriously by shading, sapping moisture, or holding large drifts of snow, thereby delaying seeding on the particular strip of field affected. The most important of these is sapping, but this can be minimized to a certain extent by thorough cultivation along the edges of the belt, by running a very deep furrow each season so as to cut off some of the spreading surface roots, and by using varieties which do not naturally have the widest spread of roots.

The feature we are most concerned with on the prairies is the protection which may be afforded from the mechanical force of the wind, and, in a lesser degree, the checking of surface evaporation by obstruction of air currents.

But what do we actually know of the exact value of tree belts in preventing soil drifting for example? This is a feature of extreme importance. During the past few years, soil drifting has caused immense losses in many parts of the three Prairie Provinces. The trouble is probably most apparent in Alberta and western Saskatchewan, where it has become a most serious problem, with every probability of danger from this source increasing unless some plan or method can be found for counteracting it.

Tree Belts and Soil Drifting

The question is, to what extent would the planting of tree belts improve conditions, and would such tree belts insure protection against damage from soil drifting. It may be taken as a fact that the effective value of a windbreak is in proportion to its height. Over twenty-five years ago, Dr. Saunders embodied in one of his reports the results of his observations at Indian Head, following a very severe windstorm, and the protection even then afforded by tree belts. He found that the protective influence was about 50 feet for every foot in height that the shelter belt grew. On a field of barley, the protective influence of the belt was very marked. The belt was about 15 feet high. The storm was a very violent one, but for a width of 750 feet out the grain was green and well protected, while beyond that it began to get thinner and for a few feet was entirely obliterated.

Suppose we assume the field to be half a mile long. The protected area would be approximately 45 acres. Where not protected, in this case, the whole crop was wiped out; so it would be reasonable to claim that an average of 30 bushels per acre was saved as a direct result of the tree belt. On the 45 acres, 1,350 bushels of barley would represent at present prices at least $1,350, while $200 would more than cover the cost of the establishment of five or six rows of trees for half a mile.

Results of Shelter Belts

A very marked case came under the observation of our officers during the past season (1919) at our nursery near Saskatoon. This nursery has only recently been established, and the main outside shelter belts have not yet attained a height of more than 6 to 8 feet. The nursery is divided into one acre plots, about 25 yards in width, with caragana hedges dividing the plots. Last summer these hedges would not average more than 2½ feet high. Of these plots, 35 were sown to oats, the land having been previously summer-fallowed. Almost adjoining these plots, on exactly the same class of soil, and with exactly the same cultivation, a ten-acre field was sown and also fifteen acres on stubble either spring or fall ploughed.

The ten-acre summer-fallowed field was completely blown out; not a bushel harvested. The stubble yielded 10 bushels per acre, while the protected summer-fallow plots threshed 1,400 bushels of oats, or 40 bushels per acre. Our superintendent, in his report, states that there was no crop to equal this anywhere in the district.

The point of chief importance in this case is the enormous influence of apparently insignificant protection. The hedges were not over 2½ feet high, a single row each, and about 75 feet apart, yet this very slight protection made all the difference between a crop of 40 bushels per acre and a total failure.

The two cases above are examples of the actual value of shelter belts in protecting against soil drift, and under similar conditions no doubt like benefits would result in almost any district.

According to data published in the United States bulletin above referred to, it was found that, actually, the average width of crop which may be protected by a belt is not more than 20 times its height. This would mean that a belt 20 feet high would protect 400 feet in width. Measurements actually made showed that with a 25-mile-per-hour wind blowing in the open, at a point five times the height away from and on the lee side of a belt of trees the wind velocity was only 5 miles per hour.

"In Marion county, Kansas, 35 or 40 years ago soil drifting threatened the usefulness of farm lands of that section. Soil drifts several feet deep can still be seen in lanes and along roads, which were at that time protected by low hedges or fences which formed traps. With the planting of many hedges of osage orange the movement of soils ceased."

Trees and Surface Evaporation

The effects of tree belts on surface evaporation are very marked, according to Bates: "The efficiency of a windbreak in checking evaporation is proportional to its density. It may save at a single point in extreme cases 70 per cent of the moisture usually lost by evaporation. . . . The distance to which protection is felt increases with wind velocity. The protection is appreciable for a distance equal to five times the height in the windward directions and fifteen to twenty times the height to leeward."*

It is suggested that evaporation from the surface of storage reservoirs in irrigated districts could be materially checked by planting good windbreaks around the borders, and particularly where water has been turned on the fields; when for the first few days conditions are particularly favourable for loss from surface evaporation, good windbreaks, may prove exceptianally valuable. "An efficient windbreak, 50 feet high, would reduce this evaporation in a field 30 rods wide to leeward by at least 30 per cent."*

I think enough has been said to show absolutely that tree belts do have an extremely important influence, both in checking soil drifting and in conserving moisture.

Can such belts be established on a sufficiently large scale to influence the comparatively large crop areas which in the past few seasons have suffered so severely and which are going to suffer more in the future unless the damaging effects of the winds can be lessened in some way?

Spacing of Tree Belts

In considering the practical side of this problem, would it be better to have wide belts spaced at comparatively long intervals, say every quarter-mile, or single rows of such varieties as caragana or spruce at comparatively close intervals of say 100 yards or 50?

The single rows at close intervals would furnish a much more uniform protection over the whole area than would wide belts spaced far apart. The actual number of plants required and the actual labour in planting would be the same in both cases. The cost of upkeep, however, would probably be greater in the case of single rows. The system followed would largely depend upon the local farming operations. If stock is kept to any extent, then the belts would require fencing, and, in such case, the cost of protecting many single rows would be practically prohibitive, and wider belts would seem to be indicated.

Systematic Tree Planting Essential

The main difficulty would not be in actually getting trees to grow, because if proper methods are followed they can be grown practically anywhere. The chief trouble will be in devising some practical system for carrying out this work on a large scale in a uniform manner. Until one looks closely into the subject, it seems a comparatively easy matter to go ahead and plant up extensive tree belts, and suggestions and advice in plenty from men with no experience is handed out freely wherever this question of wind damage is discussed.

So far as I am aware, no practical scheme has yet been put forward. It must be conceded that, to be effective, the plantings must be on a large scale over comparatively large districts. The following points must then be considered:—

1. Where is the stock to come from?

2. Who is going to do the actual planting—private individuals or organized bodies under municipal, provincial or federal control?

3. What effect would such plantings have on winter travel in certain sections where snowfall is heavy?

4. Can any uniform system be developed depending only on private enterprise? If undertaken by governmental bodies, how will the land be secured on which the belts should be planted, particularly in cases where the private owner is not in sympathy with such a movement?

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* *Windbreaks, Their Influence and Value.* By Carlos G. Bates, Bull. 86, U.S. Forest Service, Washington, 1911.

All such questions must be considered. Undoubtedly something should be done and that in the near future; undoubtedly, too, some practical method for such development can be found, if the matter is only given the consideration warranted by its great importance in relation to the agricultural development of very large areas of the Prairie Provinces.

Mr. MARNOCH: The Dominion Government has put down wells on the road allowances to prove the artesian territory. This suggests that perhaps a tree-planting experiment, in order to show its effects in preventing soil drifting—and there must be either beneficial or detrimental effects—could be carried out on road allowances, if the means could be found for instituting the experiment. It could also be carried out on a large scale along territory near this city.

H. L. PATMORE (Brandon): I have studied this matter continuously for the past thirty years. In 1889, soil drifting of the very worst description was to be found on the Brandon Experimental Farm. In a few years' time that farm, through the cultivation of trees on the west side, ceased drifting. Mr. Bedford was associated with me in 1905 on a piece of soil that blew out almost every week during the summer season, right down to hard-pan. Now, with the introduction of tree-belts, there is not a bit of drifting soil on that place, and the soil has not drifted since; even the hard-pan has come into cultivation again. Mr. Ross speaks of the advisability of more tree-belts. Last week, in the south-western portion of this province, I found men who have been there 20 or 30 years—men who have made a success. During the past six months these men have been losing much they have made. I found men to-day willing to take $25 to $30 an acre for the land, to enable them to get away. The district where I was last week was absolute prairie 30 years ago; part of it is still absolute prairie. One man who went in there had a great love for trees, and he started to plant them. A near neighbour thought, "If you can get a nice belt of trees I can go one better," and he started to grow more, with the result that to-day a tract of country 50 to 70 miles in extent is full of trees and free from soil drifting. That is a tract of country on which, during the years 1893-4-5, they had no crop whatever. The soil drifted and crops were blown out and dried out each year, but they told me on Saturday that they have never known a crop failure since the trees have grown. On one-half section there are some thirty belts. The effect the trees have had upon these farms in southwestern Manitoba has been that it has given them, although probably not heavy crops some years, yet continuous crops with no failures.

Professor CUTLER: It seems to me we have sufficient information, in the papers that have been given to-day and from observation, with respect to windbreaks, to at once consider definite ways and means under which the whole of these prairies could be systematically planted. We are past the stage where we can expect individual effort to get anywhere. That has been very well exemplified by the paper given by Mr. Ross. I could give many experiences where earnest men have endeavoured to establish windbreaks, and, after a number of seasons' efforts, they have succeeded in doing so only to lose out later because a neighbour, perhaps, summer-fallowed a piece of land on the lee side of the windbreak. It would be a pity if this conference were to break up without, in a definite way, devising some means of getting something started at once. The Governments might consider subsidizing some individual or community effort. I believe this is the moment to act. The soil-drifting problem has been presented yesterday and to-day. We appreciate it, and we appreciate the importance of solving it as soon as possible. From Mr. Fairfield's address, we know that it would be quite impossible, by crops or by any cultural methods, to stop blowing under some of these conditions where the whole fallow sliced off, or, at least, where all the soil that has been tilled has been blown away. It seems to me windbreaks would be the solution, and I would be glad to see some steps taken.

The CHAIRMAN: One must bear in mind that this Commission, as has been already said, is not an executive or an administrative body. The same committee that was appointed to consider what further experimental work would be advantageous could survey this field and bring in recommendations, and in that way get before the Commission and before the public even a more complete statement than Mr. Ross' excellent paper provided. I am sure the Commission would assent to have these questions also referred to that committee, of which Mr. Cutler is a member. Even with these excellent papers we have not enough information to go to a Government.

The Weed Menance and its Control

BY

PROF. S. A. BEDFORD

Chairman, Weeds Commission, Manitoba

WEEDS are rightly called robbers, for they deprive the soil of both food and moisture. As a rule, the soil of the west can spare some of its plant food, but, owing to the comparatively light rainfall we need all the moisture obtainable. For this reason, noxious weeds are perhaps a greater menace here than in any other portion of Canada. Owing to the extremely rich soil of the Red River valley, certain very noxious weeds, such as sow thistle and Canada thistle, thrive and spread in a most remarkable manner and frequently completely smother the crop of grain.

Farms are too large

A large proportion of the farms in all parts of the province of Manitoba are too large, and they are frequently owned by non-residents, who have very little personal interest in keeping the land clean. Tenants with short leases are often very indifferent about the condition of the land, and are a source of trouble to the inspectors. In common with all new countries offering cheap land, many inexperienced men undertake to farm for themselves, instead of first gaining experience with a successful farmer. Such men are badly handicapped from the start, and their land quickly becomes weedy. Much low-lying land, only fit for hay, is broken up each year, often in a very indifferent manner, and seeded to flax. Such fields quickly become a mat of sow thistles and other noxious weeds.

Of late years, the scarcity of farm help, high wages and inferior labour have prevented farmers from giving their land the cultivation necessary to keep down weeds. The demand for increased production since the war started has led to the cropping of fields that should have been summer-fallowed. Land in the western part of Manitoba is rapidly losing its vegetable fibre, and can not be cultivated thoroughly without leaving the soil in a condition for drifting, hence weeds thrive. The remedy for this is, of course, more grass land. Our roads are wide, and, unless the untravelled portions are broken up and seeded to grass, they soon become weedy and are a menace to adjoining farms.

Reeves and councillors of certain municipalities are very indifferent regarding the enforcement of the Noxious Weeds Act, and frequently change their weeds inspectors every year or two and pay low salaries. For instance, about one-third of the weed inspectors in Manitoba this year are new men. And last, but not least, the average Canadian farmer resents any interference in the management of his land, and is often not willing to take suggestions from others.

Control of Weeds

While an efficient Weeds Act, wisely enforced, is necessary, there must also be hearty co-operation between municipal councils and inspectors and the farmers, real estate owners, trust and mortgage companies, the different railways and both the Federal and Provincial Governments and their officials.

Control of weeds is largely a matter of education. Unless farmers learn to distinguish the different varieties of weeds, and are acquainted with the most approved methods for their eradication, there can be very little progress made in

weed control. This education may be gained through public meetings, preferably during the slack period of the year, through the press, by means of government bulletins, and, above all, through the appointment of thoroughly competent weeds inspectors engaged for a number of years at a fair salary.

The success of any Noxious Weeds Act enforcement depends largely on the class of men selected for the position of municipal weeds inspectors. Some of the best inspectors are retired farmers, past middle age, blessed with tact and good common sense, who were a success on their own farms and who understand the farm problems of the municipality. The best results are obtained when the reeve and councillors take a personal interest in the inspector and his work and have him attend all their meetings for consultation. The treatment of the council towards their inspector will be reflected in the support he gets from the other farmers.

Weed Inspection Requires Supervision

We find that the work of the weed inspectors requires constant supervision. In this province, the members of the Weeds Commission act as supervisors. This commission consists of three members, one of whom acts as chairman. The commissioners collectively decide upon all matters of policy, but divide the province for the purpose of oversight. Each member of the commission visits each municipality in his district at least once during the summer, and frequently a number of visits are necessary for certain municipalities. While on these tours, the commissioner is always accompanied in each successive municipality visited, by the local municipal weed inspector. This personal visitation of each municipality gives the commissioners an opportunity of getting first-hand information regarding the weed problems in the district, keeps them in close touch with the farming interests of the province, and enables them to assist and advise the municipal inspectors.

In spite of many drawbacks, there is in some parts of this province a noticeable decrease in the number of noxious weeds found on the better class of farms, but many of the poorly managed farms are still in bad shape, and it will take many years of energetic work to make any noticeable difference in such farms.